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RECOVERY OF FREE AMINO COMPOUNDS FROM POTATO STARCH PROCESSING WATER BY USE OF ION EXCHANGE[1]

E. G. Heisler, James Siciliano, R. H. Treadway, and C. F. Woodward

The "protein water," discharged as one of the wastes from potato starch factories, contains all the water-soluble constituents of the potato. It typically is a dilute solution containing only about 1 per cent solids. Nitrogenous compounds constitute about 60 per cent of the total solids. Approximately two-thirds of the nitrogenous constituents are free amino compounds and one-third is protein. The non-nitrogenous constituents of the protein water are sugars, acids, inorganic salts and minor constituents including polyphenolic-type compounds.

If feasible methods can be devised for recovery of useful nitrogenous compounds from potato starch factory waste water, two benefits would thereby accrue: 1) the pollutional effect of the protein water would be reduced; 2) the economics of potato starch processing would be improved through the creation of salable by-products. In removing the nitrogenous substances from the potato processing water, one can consider the alternatives of preparing a concentrate containing several of the principal amino compounds and of isolating purified individual compounds. Certain of these free amino compounds, for example asparagine and glutamine, give some promise of finding medicinal applications. A concentrated mixture of the principal amino compounds, in addition to potential pharmaceutical uses, might also be of value as a nutritional supplement, food flavoring agent, or nutrient in industrial fermentations.

Another approach to the problem of utilization of potato starch factory soluble wastes is to evaporate under reduced pressure most of the water in the effluent to provide a soluble concentrate. Although this work is not reported in the present paper, we found it possible to make a fluid, stable concentrate containing as high as 60 per cent solids. It is apparently better, from the standpoints of stability and fluidity of the product, to remove the protein by heat coagulation before preparing the concentrate. Since such a concentrate contains most of the potato solubles, conversion of the plant effluent to a concentrate would greatly reduce the pollutional problem. We have information that a concentrate containing all the non-coagulable solubles of potato processing water should be useful as a nutrient in fermentations.

Our interest in this study lay in the free amino compounds of this processing water. The composition of potato extracts with respect to free amino compounds has been investigated by various workers. Using partition chromatography Dent, Stepka, and Steward (3) reported the presence of 24 amino compounds in the soluble, non-protein fraction of the potato. Thompson and Steward (10) presented quantitative data obtained by paper chromatographic technique. They reported the following percentages based on the percentage of nitrogen: glutamine, 46.9; asparagine, 23.6; arginine,

[1]Accepted for publication May 12, 1958.

[2]Eastern Utilization Research and Development Division, Agricultural Research Service, United States Department of Agriculture, Philadelphia 18, Pa.

9.3; ammonia, 4.2; γ-amino butyric acid, 3.3; valine, 2.4; alanine, 1.7; glutamic acid, 1.4; threonine, 1.0; lysine, 1.0; phenylalanine, 1.0; aspartic acid, 0.9; leucines, 0.9; tyrosine, 0.8; serine, 0.7; methionine, 0.6; glycine, 0.4, and a trace of proline.

Procedure and Analytical Methods

Preliminary work was carried out on processing water received from Maine starch factories. It is necessary to use an additive, such as sodium benzoate, to preserve the processing water during shipment. In addition to the inconvenience of transporting a dilute solution a long distance, possible compositional changes present an uncertainty. Hence, it was decided to simulate processing water in the laboratory by preparing dilute potato extract. Washed potatoes were ground in a hammer mill; the slurry was treated with sulfur dioxide, and basket-centrifuged to recover the juice. The centrifuge cake was then washed with water using one-third as much as the weight of potatoes ground, and the washings added to the straight juice.

The diluted juice was treated with acid or heat to coagulate the protein. After the protein was filtered off, the liquor was diluted to 1 per cent total solids and run through Dowex 50[1,2] (H^+ form) ion-exchange resin. The effluent was collected and set aside. The column was washed with water and the washings added to the effluent. The column was next eluted with ammoniacal solution.

All solutions on which data are reported here were analyzed by the following methods:

Total nitrogen was determined by the microkjeldahl method (5). The free ammonia content of the eluate was estimated, after appropriate dilution, by direct titration using the microkjeldahl titration technique. Total solids content was determined by heating to dryness in a forced-draft oven at 80° C. followed by one hour in a vacuum oven at 80°. Ashing was carried out at 650° for five hours. The content of total polyphenols was determined using the method of Rosenblatt and Peluso (8). The latter method was modified, however, to the extent that chlorogenic acid was used instead of tannic acid as the standard for determining the amountof polyphenols present. This was done since chlorogenic acid is the major polyphenol in potatoes. Total sugars content was determined by the Java Sugar Experiment Station method (2).

The free amino compounds were studied qualitatively by the small scale, two-dimensional paper chromatographic technique of Rockland and Underwood (7). Paper sheets ("S and S 589 Blue Ribbon") 5½ inches square were suspended in number 4 American Medical Museum jars by means of wooden dowels passed through two holes punched in the top of the paper. The solvents used were: (I)—tertiary butyl alcohol-water-formic acid (69.5-29.5-1) and (II) —phenol-water-ammonium hydroxide (73.5-20.5-1). After irrigation in the above solvents and drying, the papers were dipped in 0.75 per cent ninhydrin solution in water-saturated N-butanol to detect the amino compounds.

[1]Mention of trade names in this paper does not imply that these products are recommended or endorsed by the U. S. Department of Agriculture over others not mentioned.

[2]The Dowex 50 resin used in all experiments was labeled, "Absorbent for Chromatography," and obtained from the Will Corp., Rochester 3, N. Y.

The above qualitative paper chromatographic technique was extended to yield a quantitative estimation of the amounts of aspartic acid, glutamic acid, asparagine, glutamine, and γ-aminobutyric acid plus valine (determined as valine.) Gamma-aminobutyric acid and valine were also determined separately by a one-dimensional technique using n-butanol-water-acetic acid (8-10-1). There are many references in the literature to quantitative paper chromatography of amino compounds. After some experimentation, we found the following procedure to give satisfactory results. The solution was applied to the paper with micropipettes. After irrigation in the appropriate solvents and drying, the color was developed by dipping the papers in 0.75 per cent ninhydrin in water-saturated n-butanol and drying for 2 hours at room temperature. The spots were cut out and put into test tubes, and the color extracted from the paper with 50 per cent aqueous n-propanol at room temperature. The intensity of the colored solution was read in a Beckman B Spectrophotometer at 570 mu for all the amino compounds except asparagine, which was read at 365 mu. Standard solutions were run daily to correct for any small variation that might occur in the standardized conditions.

Development of Optimum Conditions and Discussion of Results

Extraction.

In the preparation of simulated processing water, juice can be separated from the ground potato slurry by basket-centrifuging directly without any dilution. Using one lot of Maine Russet potatoes, an undiluted extract containing 4.6 per cent solids was obtained. This amounted to a yield of 2.8 per cent of soluble solids based on weight of fresh potato. On washing the centrifuge cake (without resuspension) the yield was increased as shown in table 1.

It is seen that 76 per cent of the soluble solids was obtained without any washing. The yield was increased to 89 per cent by washing with water equivalent to one-third the weight of potatoes ground and to 93 per cent by washing with twice this much water. Further washing increased the yield only slightly.

Table 1.—*Yields of potato solubles using various amounts of water to wash centrifuge cake.*

Ratio Wt. Wash Water *vs.* Wt. Potato Slurry	Yield Based on Wet Potato	Theoretical Yield
	Per cent	Per cent
0 : 3	2.80	76.0
1 : 3	3.28	88.9
2 : 3	3.44	93.2
3 : 3	3.49	94.5

*The theoretical yield is calculated by assuming that the amount of juice potentially available is equal to the weight of potato multiplied by its moisture content divided by 100. This volume of juice multiplied by the solids content (divided by 100) of the juice obtained by basket-centrifuging the straight slurry equals the theoretical yield of soluble solids.

Detection of Amino Compounds

Using the paper chromatographic procedure outlined above, a study was made of the amino compounds in protein water samples prepared from several different varieties of potatoes. The general pattern was the same for all the varieties. In all, about 20 spots were obtained on treating the paper with ninhydrin; however, all but three of the spots were very faint. Principally from data obtained with known compounds, it was ascertained that the three intense spots represent asparagine, glutamine, and a combination of γ-aminobutyric acid, valine, and a small amount of methionine. Using the solvent system n-butanol-water-acetic acid (8-10-1) γ-aminobutyric acid and valine were separated. Typically there is more γ-aminobutyric acid present than valine; however, both are present in considerable quantity. The methionine remained with the valine. Its presence was detected by treatment with platinic iodine reagent (1). The quantity of methionine is very small compared to γ-aminobutyric acid and to valine. It was found that the six amino compounds aspartic acid, glutamic acid, asparagine, glutamine, γ-amino-butyric acid and valine, constitute approximately 20 per cent of the total solids and 50 per cent of the total nitrogen of the protein water.

Protein Removal

Acid vs. Heat

Protein must be removed prior to ion-exchange treatment of potato juice to prevent its precipitation on the column and resultant clogging. The simplest methods of carrying out the precipitation are by heating to about 80° or acidification to pH of 3.0 or slightly below. The acid required to lower the pH of 1 per cent solids processing water to 3.0 is about 3 milliliters of concentrated HCl/1000 mls. liquor. Investigation of both the acid and heat treatment led to the conclusion that neither method resulted in any appreciable hydrolysis of the protein or conversion of the free amides (asparagine and glutamine) to the acids or the ring compounds. Using an extract of Pennsylvania Katahdin potatoes, believed to be typical of eastern potatoes, the acid treatment removed 11.3 per cent of the solids and the heat treatment, 24.2 per cent. The acid treatment removed 23.3 per cent of the total nitrogen and the heat treatment, 32.3 per cent. All data indicated that heat is the more complete precipitant. This is in agreement with the results of others (4, 9). Acidification at ordinary temperature precipitates only the difficultly soluble protein, leaving much of the globulin and albumin in solution whereas the heat treatment precipitates practically all the protein. However, although acid precipitation is not complete, it is sufficiently complete for preventing clogging of the ion-exchange column.

When the potatoes are treated with sulfur dioxide immediately on grinding, the deproteinized liquor subsequently obtained, either by acid or heat treatment, is light yellow and needs no decolorization. A disadvantage of the acid treatment is that a filter aid must be used to filter the precipitated material. As for subsequent behavior of the liquor on the ion-exchange column, there is no appreciable difference between the two methods of removing protein.

Amino Compounds in Non-protein Fraction.

The principal amino compounds of heat-deproteinized liquor were determined quantitatively by the small scale, two-dimensional paper chromatographic technique. Table 2 gives the data obtained with five varieties of potatoes from different growing areas.

It should be noted that with the five eastern-grown lots of potatoes, the relationships of the amounts of the amino compounds to one another within a lot were similar. The asparagine content was greater than the glutamine in all five cases. However, the California White Rose potatoes had more glutamine than asparagine and were much higher than the eastern potatoes in total amino compounds content. With the thought that perhaps some glutamine had been converted to the ring compound pyroglutamic acid (non-reactive with ninhydrin), the procedure of Rydon and Smith (9) was used in the attempt to detect the latter substance. No pyroglutamic acid was detected, though, in any of the samples.

TABLE 2.—*Amino compounds in deproteinized potato processing water (mg/100 mls. of 1 per cent solids liquor)*

	Maine Russet		Maine Kennebec	Pa. Katahdin	Del. Katahdin	Calif. White Rose
	(a)	(b)				
Aspartic acid	14	13	17	10	8	13
Glutamic acid	6	12	15	17	15	3
Asparagine	89	94	131	162	85	140
Glutamine	63	55	92	46	45	195
γ-Aminobutyric acid + Valine (as valine)	36	20	36	46	22	76
Total	208	194	291	281	175	427

*Separate lots.

Ion Exchange Treatments

Charging the Column.

By passing deproteinized potato liquor through Dowex 50 (H^+ form) resin and eluting under proper conditions, it can be purified and concentrated with respect to the free amino compounds. A column 1-inch inner diameter containing 300 ml. of the wet commercial grade resin (123 g. dry weight) was used. This quantity of wet resin filled the column to a height of 23 inches.

All the amino compounds and inorganic cations were retained on the resin; the effluent containing the sugars, organic acids, and minor constituents including polyphenols was discarded. The resin was eluted with ammoniacal solution. This removed the amino compounds but left the inorganic cations on the column. The column could then be regenerated with dilute hydrochloric acid and the cycle repeated.

Our laboratory-simulated processing water, prepared by combining undiluted juice centrifuged from ground potatoes with washings from the centrifuge cake typically contained 3.7 per cent solids. To standardize conditions and enable the collection of data at the same concentration as

found in commercial practice, the laboratory-prepared deproteinized liquor was diluted to 1 per cent solids for use in all experiments reported. A few experiments conducted with potato liquor at 3 - 4 per cent solids concentration indicated that the results in adsorption and elution were essentially the same as with 1 per cent solids. It would be much more economical, of course, to base a product recovery process on the more concentrated liquor if the potato starch industry can provide such an effluent by adjusting its operations.

The relationship between the flow rate of the liquor and the capacity of the column to adsorb nitrogenous compounds was studied. A concentration of 15 mg. N/100 ml. effluent was taken as the threshold of nitrogen outgo, beyond which the capacity of the column would be considered exceeded. As would be expected, the capacity of the column was reduced as the flow rate was increased. Nitrogen-concentration values of the effluents are plotted against effluent volume data in figure 1. Taking 15 milligrams N/100 milliliters as the maximum allowable nitrogen in the effluent, the capacities of the column using flow rates of 2, 4, 5 and 6 liters/hour were respectively 6.5, 6.2, 5.9 and 4.2 liters of 1 per cent juice. These results were obtained with juice that had been deproteinized with acid. Heat-deproteinized juice gave essentially the same values.

The flow rate can also be expressed in terms of contact time, i.e., time in minutes that the liquor is in contact with the resin. Thus, the contact time is equal to the volume of liquor (in liters) required to wet the column of resin multiplied by 60 (minutes), divided by the flow rate in liters per hour. The contact times at flow rates of 2, 4, 5 and 6 liters/hour were 2.7, 1.35, 1.08 and 0.9 minutes respectively.

Eluting the Column

Here, two methods of approach presented themselves: 1) fractionation of the non-protein nitrogen group into the individual amino compounds and 2) stripping the amino compounds collectively. The first technique is necessarily complicated and would involve very dilute eluting reagents and a very slow flow rate. The amino compounds would thus be recovered in dilute solution, probably much more dilute than the original processing water. The second method, i.e., stripping the amino compounds collectively from the column, enables the use of a minimum volume of the ammoniacal eluting agent. A concentrated solution of a mixture of amino compounds is thus obtained.

The alternative of fractionating the amino compounds was investigated by use of the procedure of Partridge (6), essentially without modification. The column of Dowex 50 resin (300 ml.) was loaded to one-third its capacity, that is, by passing through 2 liters of 1 per cent deproteinized liquor. A relatively slow flow rate of 1 liter/hour was used. The column was washed with 1 liter of water, then eluted with 0.15 normal ammonium hydroxide (NH_4OH). Sixty-nine fractions of 100 ml. each were collected. Fractions 1 to 21 contained no amino compounds. Fractions 22 to 61 gave a positive ninhydrin test. Small-scale, two-dimensional chromatograms were run on selected fractions and from the information gained regarding the amino compounds content it was apparent that very little fractionation had been obtained. Aspartic acid came off alone in the early ninhydrin-active fractions; however, the middle fractions contained a mixture of

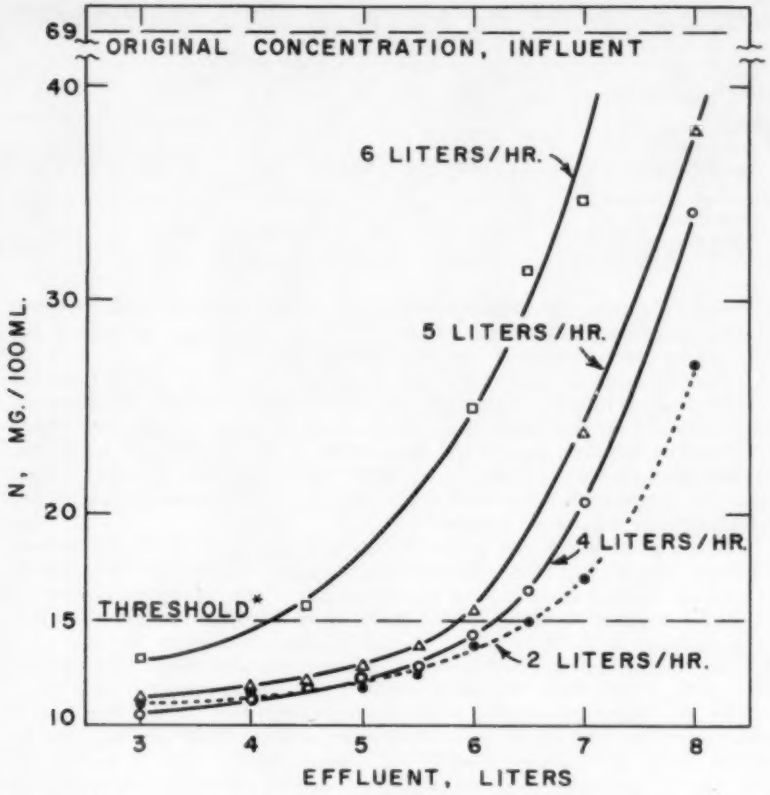

FIGURE 1.—Concentration of nitrogen in effluent from column at different rates of flow.

*This value taken as maximum allowable nitrogen concentration in effluent without considering the capacity of the column exceeded.

glutamic acid, asparagine and glutamine. The middle fractions were also rich in γ-aminobutyric acid and valine.

The basic amino compounds came off last, in fractions 43 to 61. The highest concentration of solids obtained in the eluate was 0.33 per cent, found in one of the middle fractions.

From the results of this preliminary fractionation work, it was decided to concentrate on the other alternative, that of eluting the amino compounds as quickly as possible. A series of experiments was carried out of which the concentration of NH_4OH (ammonium hydroxide) was varied from 0.6 to 2.5 normality (Table 3). The column was loaded to capacity, washed with water, and then eluted with the aqueous ammonia. A flow rate of 2 liters/hour was used in this set of experiments. Fractions

TABLE 3.—*Elution of amino compounds from resin columns, using various concentrations of NH_4OH.*

NH_4OH normality	0.6	1.0	1.5	2.0	2.5
Max. concen. in any fraction, per cent solids	4.8	8.5	10.7	14.3	14.6
Total vol. fractions containing min. of 1 per cent solids, ml.	700	500	450	350	350

of eluate containing 50 milliliters each were collected and the solids content of each fraction determined. All the fractions containing at least 1 per cent solids were combined and the others discarded.

The amounts of total solids and of amino compounds eluted from the column were substantially the same for all the concentrations of ammonia, and furthermore, the amounts of the individual amino compounds eluted remained essentially constant throughout the range of NH_4OH used. The elution data shown in table 3 indicated that 2 normal NH_4OH is the optimum concentration for eluting the column in that it elutes the amino compounds in minimum volume.

The rate at which the amino compounds are eluted from the column does not depend on the concentration of ammonia alone. The immediately preceding data on the effect of the normality of the ammonium solution on the concentration of the eluate were taken with the elution flow rate held constant at 2 liters/hour. Elution of loaded columns by use of 2 normal ammonium hydroxide was then carried out employing various flow rates. The volume of eluate required to remove substantially all of the amino compounds varied from 500 milliliters at 5 liters/hour to 350 milliliters at 2 liters/hour. No reduction in eluate volume was attained by eluting at a rate slower than 2 liters/hour. Hence, the 2 liters/hour flow rate is the optimum for obtaining the amino compounds in minimum volume of eluate.

CONCENTRATING AMINO COMPOUNDS BY METHODS DEVELOPED

Table 4 presents data on a typical experiment in concentrating amino compounds of potato liquor using optimum methods of charging and eluting the column. Six liters of acid-deproteinized liquor from Maine Russet potatoes was passed through the resin column at the rate of 5 liters/hour. The resin was washed with 1 liter of water and then eluted with ammonia.

Eluate fractions 6-12 inclusive (Table 4) were retained and the others containing less than 1 per cent solids each were discarded. The 350 milliliters composite of the seven more concentrated fractions contained 16.3 grams solids. This represented a recovery of 28 per cent of the solids passed through the column. It is seen that the original liquor contained 3.8 grams nitrogen and the eluate 2.9 grams providing a recovery of 76 per cent. The weight of nitrogen present in the effluent plus the washings, 0.77 grams, represented a loss of 20 per cent of that originally present. This loss of nitrogen through failure to be adsorbed on the column ap-

TABLE 4.—*Concentrating amino compounds by ion exchange in resin*-packed column.*

		Volume		Total solids		Nitrogen	
		Mls.		Per cent	Gms.	Per cent	Gms.
Deproteinized liquor passed		6000		0.97	58.4	0.064	3.84
Effluent plus wash water		7000		0.35	24.5	0.011	0.77
Retained on column					33.9		3.07
Eluate**—fractions	1	50		..			
	2	50		..			
	3	50		0.01			
	4	50		0.16			
	5	50		0.36			
	6	50		1.83	0.92		
	7	50		4.43	2.22		
	8	50		6.54	3.27		
	9	50	350	8.26	4.13	16.3	0.818 2.86
	10	50		7.69	3.84		
	11	50		2.61	1.30		
	12	50		1.28	0.64		
	13	50		0.49			
	14	50		0.40			
	15	50		0.21			

*Dowex-50, H+ form.
**Eluted with 2 normal NH_4OH at 21./hr.

parently is not connected with any conversion of glutamine to pyroglutamic acid, as indicated by the Smith-Rydon test (9). Only 4 per cent of the nitrogen introduced to the column was lost in discarding the dilute fractions. The basic amino acids are rather tightly held by the resin and were thus largely eluted in the last fractions in dilute form. These compounds include arginine, lysine, and histidine.

The factor 6.25 is believed to hold fairly well for converting nitrogen weight to amino compounds weight in the eluate. If the weight of nitrogen in the composite of fractions 6-12 (Table 4) is multiplied by 6.25, a somewhat larger figure but still a fair approximation to the weight of the total solids is obtained. This indicates that the solids content of these middle fractions is high in amino compounds.

Table 5 compares the composition of the deproteinized liquor with the eluate. The total solids content was increased 4.65-fold and the amino compounds content, 12.7-fold by the ion-exchange treatment. The eluate contained predominately amino compounds with very small amounts of sugars, inorganic salts, and minor constituents including polyphenols. The six amino compounds listed comprised 20 per cent of the total solids of the deproteinized liquor and 58 per cent of the total solids of the eluate.

RECOVERY OF INDIVIDUAL AMINO COMPOUNDS FROM THE ELUATE

Ion exchange methods described above can thus be made to yield the amino compounds of potatoes in relatively concentrated solution, essentially free of contamination by other types of substances. Besides the six amino

TABLE 5.—*Composition of deproteinized potato liquor and corresponding eluate.*

	Deproteinized liquor		Eluate*	
Volume ml.	6000		350	
Total solids, Per cent	0.97		4.65	
	Per cent		Per cent	
	W.B.	M.F.B.	W.B.	M.F.B.
Amino compounds (N x 6.25)	0.40	40.8	5.1**	
Ash	0.22	22.6	0.02	0.43
Sugars	0.31	32.0	0.10	2.15
Polyphenols	0.03	2.8	0.23	4.58
Individual amino compounds				
Aspartic acid	0.01	1.3	0.31	6.6
Glutamic acid	0.01	1.2	0.15	3.1
Asparagine	0.09	9.7	1.34	28.8
Glutamine	0.06	5.7	0.59	12.8
γ-aminobutyric acid plus valine	0.02	2.1	0.30	6.5
		20.0		57.8

* Composite of fractions 6-12 of table 4.
**6.25 conversion factor results here in somewhat higher value for amino compounds than total solids.

compounds listed in table 5, the eluate also contains other amino compounds including alanine, threonine, leucine, isoleucine, tyrosine, serine, methionine, glycine, arginine, histidine and lysine.

Asparagine can be recovered in nearly 100 per cent yield as crystals containing 90 per cent asparagine by concentrating the eluate to 45 per cent solids and chilling to approximately 35°. (Asparagine can also be separated from a crude concentrate of potato solubles by similar treatment, but the yield is lower.) The main contaminant of these crystals is glutamine. Pure asparagine can be obtained by taking up the impure crystals in a minimum amount of hot water and allowing the solution to cool slightly, upon which asparagine crystallizes out and glutamine remains in solution.

After removal of the asparagine by chilling the concentrated eluate to 35° and filtering off the crystals, the remaining liquor is again cooled upon which impure glutamine is obtained. This second crop of crystals is about 90 per cent pure with respect to glutamine, but represents only a minor part of the total glutamine present.

After removing the asparagine and crystallizing out part of the glutamine, crude aspartic acid can be obtained. The concentrated eluate (40 to 50 per cent solids) is acidified to pH 3 and enough ethanol added to yield a solution containing 60 per cent ethanol.A crystalline mass then separates, containing about 80 per cent aspartic acid. The main contaminants are glutamic acid and glutamine. Aspartic acid can be recovered from the eluate in 60 per cent yield.

SUMMARY AND CONCLUSIONS

Ion exchange methods have been developed for concentrating the free amino compounds in dilute potato extract simulating starch factory

processing water. The solubles are extracted from ground, sulfited potatoes by centrifuging and washing the centrifuge cake with water equal to one-third the weight of potatoes ground. The combined juice and washings typically contain about 3.7 per cent total solids. This extract was diluted to 1 per cent to conform to the concentration of commercial starch processing water. The protein was removed by heat coagulation to prevent clogging during subsequent passage of the liquor through an ion-exchange column.

The amino compounds were concentrated and separated from most of the other potato solubles by absorption on Dowex 50 resin (H+ form) followed by elution with 2 normal NH_4OH. The middle fractions of the eluate were rich in asparagine, glutamine, aspartic acid, glutamic acid, γ-amino-butyric acid, and valine. Thus, in a typical experiment, 28 per cent of the total solids and 75 per cent of the amino compounds originally present in 6000 ml. of dilute liquor were recoverable in 350 milliliters of eluate combined from the middle fractions. The total solids content of this eluate was nearly five times and the amino compounds content, thirteen times the corresponding values of the original dilute liquor.

Amino compounds comprised most of the solids in the composite of middle fractions of the eluate. Half of the weight of amino compounds was present as the six previously-named compounds.

Nearly all of the asparagine, the most abundant amino compound present, can be easily recovered in 90 per cent-pure form. The composite of the middle fractions of the eluate is concentrated to 45 per cent solids or higher and chilled to about 35° C. to induce crystallization. Recrystallization results in nearly 100 per cent pure asparagine. Glutamine and aspartic acid were also recoverable by simple crystallization procedures.

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NORLAND
A NEW RED-SKINNED POTATO VARIETY WITH EARLY MATURITY AND MODERATE RESISTANCE TO COMMON SCAB[1]

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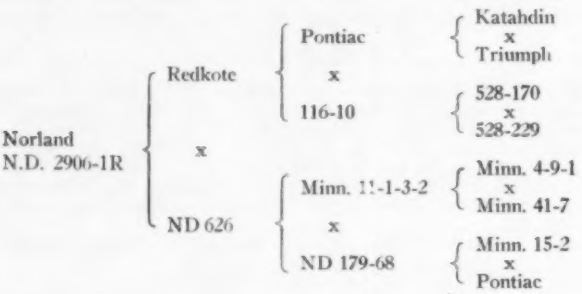
On August 1, 1957 Norland (Figure 1) was released by the Horticulture Department, North Dakota Agricultural College, Fargo, North Dakota.

Early maturity and the ability to produce high marketable yields early in the season are some of the important characteristics of the variety. In maturity Norland is similar to Red Warba.

Norland was tested in North Dakota and other areas under the pedigree number ND 2906-1R. It is a selection from a cross between Redkote and ND 626. Redkote is a smooth, red-skinned variety with moderate resistance to common scab. ND 626, a selection discarded in 1951, possessed good red color, smooth tuber type and moderate resistance to common scab. This cross was made in 1950 in the horticulture greenhouse at the North Dakota Agricultural College and the seedlings from the cross were grown in the greenhouse the same year. The seedlings were grown in the field at the Langdon Branch Station, Langdon, North Dakota, in 1951, at which time the original selection was made.

The Pedigree of Norland follows:



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DESCRIPTION

PLANTS: Medium large, spreading; *stems*, medium thick, prominently angled; *nodes*, slightly swollen, green; *internodes*, green; *wings*, slightly waved, green; *stipules* on leaves, medium size, clasping, green; *leaves*, medium large, slightly closed, green, scantily pubescent; *terminal leaflets*, medium, broadly ovate, acute lobed and slightly asymmetrical;

FIGURE 1.—Tubers of variety Norland.

primary leaflets, medium large, ovate, 3 pairs, mean length 55.8 ± 0.99 mm. (2.20inches), mean width 34.9 ± 0.65 mm. (1.37 inches), with index width to length 63.9 ± 0.55 mm. *Petiolules*, green, slightly pubescent; *secondary leaflets*, many, between pairs of primary leaflets; *tertiary leaflets*, many; *inyorescence*, branched; *leafy bracts*, green, scantily pubescent; *peduncles*, in axils of main stem, long, slightly pubescent; *pedicels*, medium long, scantily pubescent; *corky ring*, conspicuous with reddish pigment.

FLOWERS: *Buds*, green; *calyx lobes*, medium in length (4-7 mm.), tips slightly curved, pubescent; *corolla*, medium large (20-30 mm.), purple, spreading; *anthers*, medium large, orange, pollen abundant and of fair quality; *style*, straight; *stigma*, medium large, globose and green.

TUBERS: Medium oblong, slightly flattened, medium thick, mean length 86.5 ± 0.57 mm. (3.41 inches), mean width 75.0 ± 0.37 mm. (2.95 inches), mean thickness 58.8 ± 0.38 (2.32 inches), indexes width to length 87.2 ± 0.73, thickness to length 68.3 ± 0.70 and thickness to width 78.5 ± 0.62. *Skin*, smooth, red; *eyes*, shallow; *eyebrows*, medium long curved, medium prominent; *flesh*, white; *sprouts*, slightly purple at base when developed in the dark; *maturity*, early.

CHARACTERISTICS

The most important characteristics of Norland are its moderate scab resistance, red skin color, tuber type, early maturity and the ability to produce high marketable yields early in the season. In maturity, Norland is comparable to Red Warba and Waseca and approximately 15 days earlier than Red Pontiac. The variety is suitable for a late as well as an early crop and produces a high percentage of U. S. No. 1 tubers. The plant growth is medium large and spreading with rapid emergence following planting. Under some conditions Norland has the tendency to grow long stolons. Tubers are medium oblong in shape and very smooth with an even distribution of shallow eyes. The intensity of the red skin color has varied at different locations in North Dakota and other areas. This variety seldom

produces tubers that are irregular in shape, knobby or growth cracked and the tubers are not susceptible to internal defects like hollow heart, internal necrosis and vascular discolorations.

Tests in North Dakota and other areas have shown that Norland has moderate resistance to common scab. Silver scurf has been common on this variety in North Dakota. Norland is susceptible to infection by the common potato viruses and to the fungus causing late blight.

Yield and Other Comparisons

Since 1954 Norland has been tested for yield and per cent total solids in North Dakota and other areas. As shown in table 1, Norland, grown in North Dakota, outyielded Red Pontiac and Triumph when harvested on August 15. Yields were sufficiently high for growers to market Norland profitably during mid-August. When harvested in mid-September at Park River, Grand Forks and Williston (irrigation), North Dakota, Norland outyielded Triumph but not Red Pontiac.

In 1956 and 1957 Norland was tested in nine states of the North Central Region. The tests were conducted on peat soils in Iowa and Indiana and on mineral soils in Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio and Wisconsin. Two years' yield data from these trials showed Norland to have an average U.S. No. 1 yield of 390 bushels per acre compared to Triumph with 379, Irish Cobbler with 380 and Red Pontiac with 525. Norland was rated high for general appearance in Missouri, Iowa and North Dakota. U.S. No. 1 yield of Norland and 3 standard varieties grown in the North Central Regional Variety Trial, 1956 and 1957, are presented in table 2.

A comparison of the percentages of total solids as recorded in Table 1 reveals that Norland is comparable to Triumph and slightly higher than Red Pontiac. Norland has been fair for baking and excellent for boiling and frying. Samples of Norland were tested for chipping quality in 1956 and 1957. When chipped immediately after harvesting in August, chips produced from Norland were lighter in color than Irish Cobbler but comparable to Kennebec. Chipping tests also indicated that Norland will produce suitable chips when harvested late and after a period of storage and reconditioning. Chip yield of Norland was generally lower than that of Irish Cobbler.

Summary

Norland is an early maturing, smooth, shallow-eyed, red-skinned variety with early yielding ability. It has moderate resistance to common scab and is susceptible to infection by the common potato viruses and to the fungus causing late blight. This variety possesses good cooking and chipping qualities and produces a high per cent of U.S. No. 1 tubers.

TABLE 1.—*Average yields and per cent total solids* of four potato varieties grown at three locations in North Dakota and harvested on two dates, 1955 and 1956.*

Variety	Grand Forks and Park River				Williston (Irrigated)	
	Early Harvest 8/15		Late Harvest 9/15		Late Harvest 9/15	
	U.S. No. 1 Yield Per/Acre	Total Solids	Total Yield Per/Acre	Total Solids	Total Yield Per/Acre	Total Solids
	Bushels	Per cent	Bushels	Per cent	Bushels	Per cent
Norland	241	19.3	334	18.1	516	19.3
Red Pontiac	219	18.4	380	18.1	620	18.4
Triumph	232	19.6	325	18.5	458	19.0
Early Gem	147	18.4	294	17.9	468	19.0

[1]Yields and per cent total solids of locations and years averaged.

TABLE 2.—*U.S. No. 1 yield of Norland and three standard varieties grown in the North Central Regional Variety Trials, 1956 and 1957.*

Location	Yield Per Acre U.S. No. 1 (1956)				Yield Per Acre U.S. No. 1 (1957)			
	Norland	Triumph	Red Pontiac	Irish Cobbler	Norland	Triumph	Red Pontiac	Irish Cobbler
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
Iowa	451	363	718	634	431	477	611	764
Michigan	601	672	833	564	254	80	258	285
Minnesota	295	344	423	234	200[1]	128[1]	246[1]	185[1]
Missouri	494	462	490	493	253	98	301	259
Nebraska	150	254	264	45	257	98	252	14
North Dakota	314	328	435	285	316	317	415	373
Ohio	410	..	562	334	410	426	568	467
Wisconsin	422	443	598	308	515	479	436	423
Indiana[2]					675	820	1231	602
Average	392	409	540	362	389	349	509	398

[1]Total yield not U.S. No. 1.
[2]Data omitted because of poor stand .

A SURVEY OF RUGOSE MOSAIC AND LEAF ROLL VIRUS DISEASES OF POTATO IN WEST BENGAL — IN PLAINS[1]

S. B. CHATTOPADHYAY AND C. R. DAS[2]

In a previous article the authors (2) gave a general account of various virus diseases occurring on major agricultural crop plants in West Bengal. In this article they pointed out that of the various virus diseases affecting potatoes in West Bengal, rugose mosaic and leaf roll are widespread in occurrence and cause extensive losses in yield. In view of the seriousness of these two virus diseases, a survey was undertaken in the winter of 1955-1956 to estimate the percentage of infection, loss in yield, *etc*. In the present paper an account has been given on the observations of the survey made on rugose mosaic and leaf roll diseases in the field in the State of West Bengal.

SELECTION OF PLOTS

The survey work was carried out in the potato belt of the districts of Hooghly and Burdwan, which comprise nearly fifty per cent of the total cultivated area devoted to the crop in the State. Observations were made on the potatoes grown in the farmers' fields and for the purpose a plot size of 1/12th of an acre was chosen. The plots which have been sprayed against blight diseases and the plots in which the virus affected plants were rouged out were not selected. The plots in a particular locality were selected at random. In the district of Hooghly seven localities with seventeen plots and in the district of Burdwan three localities with four plots were selected. About fifty per cent of the observational plots had to be discarded later due to heavy incidence of blight during the period of study.

METHOD OF CULTIVATION

Cut tubers are generally sown for the production of late varieties and whole tubers in the case of the early variety. Sowing generally starts in November and continues up to the middle of December depending upon the variety. Harvesting is usually done during the months of February and March depending on the locality. The plants are usually six inches apart in a row while the rows are approximately twenty inches apart on an average.

OBSERVATIONS

The first observation was recorded when the sprouts came above the ground level and were continued at intervals of seven days until the plants began to attain senescence before harvesting. Observations were made on three major varieties of potato grown in the State e.g. *Darjeeling Red Round* (very early), *Up-To-Date* (medium) and *Royal Kidney* (late). The observations were made on the following points:

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a) Appearance of initial infection and age of the plant.
b) Progress and percentage of infection of rugose mosaic and leaf roll and peak period of infection.
3) Loss in yield due to rugose mosaic and leaf roll infection.

Appearance of Initial Infection and Age of the Plant

It may be seen from table 1 that the first symptoms of infection of rugose mosaic were observed in the field between the last week of December and the first week of January except in one case where the symptom was noted in the second week of January. Infection of leaf roll was noted mainly in the first and second week of January. In three cases appearance of leaf roll was as late as the third week of January, whereas in one case it appeared in the fourth week of December. It may be stated that leaf roll appeared later (1-3 weeks) than rugose mosaic.

TABLE 1.—*Initial infection and age of infection.*

Variety	Locality	Initial Infection		Age of Infection in Weeks from Date of Sowing	
		Rugose Mosaic	Leaf Roll	Rugose Mosaic	Leaf Roll
Royal Kidney	Tegri	2. w. Jan.	M. 3. w. Jan.	7	8
	Durgaprosad	4. w. Dec.	L. 1. w. Jan.	4	5
	Memari	1. w. Jan.	2. w. Jan.	5	6
Darjeeling Red Round	Sahpur	4. w. Dec.	1. w. Jan.	4	6
	Durgaprosad	4. w. Dec.	1. w. Jan.	4	6
	Gouribati	4. w. Dec.	1. w. Jan.	6	8
	Kamarkundu	1. w. Jan.	2. w. Jan.	5	6
	Basudevpur	1. w. Jan.	2. w. Jan.	5	6
	Daluibazar	4. w. Dec.	2. w. Jan.	4	7
Up-To-Date	Durgaprosad	1. w. Jan.	3. w. Jan.	6	8
	Memari	4. w. Dec.	L. 4. w. Dec.	5	6
	Baidyadanga	4. w. Dec.	3. w. Jan.	3	6

W. = week. M = mid. L = late.

It would be seen from the above table that the variety Royal Kidney showed the first symptom of infection of rugose mosaic and leaf roll at the age of 7 and 8 weeks and 4 and 5 weeks at Tegri and Durgaprosad (Hooghly), respectively, whereas the same variety at Memari (Burdwan) showed symptoms when they were 5 to 6 weeks old, respectively. *Darjeeling Red Round* showed symptoms of rugose mosaic and leaf roll at the age of 4, 5, 6 weeks and 6, 8, 7 weeks, respectively, at Sahpur, Durgaprosad, Kamarkundu, Basudevpur and Gouribati (Hooghly) and Daluibazar (Burdwan). No infection was observed in Up-to-Date at Gouribati, but at Durgasprosad (Hooghly) the infections of rugose mosaic and leaf roll were observed at the age of 6 and 8 weeks, respectively, whereas at Memari and Baidyadanga (Burdwan) they showed the initial infections of rugose mosaic and leaf roll at the age of 5 and 6, 3 and 6 weeks, respectively. It may be seen that the age of the plant does not apparently have any direct

correlation with the appearance of the disease. On the other hand, the appearance of the disease is greatly influenced by the initial infestation of vectors, which appear about the 3rd to 4th week of December, Banerjee and Basu (1).

Progress and Percentage of Infection of Rugose Mosaic and Leaf Roll and Peak Period of Infection.

The infection data were recorded on plants at seven days' interval from the time of the first appearance of the symptoms. However, observations were continued until the symptoms were still recognizable, until just before harvesting operations.

Vasudeva and Azad (5) stated that 15 per cent infection of severe type of mosaic was observed at Burdwan during 1943-44. In 1945 the infection was 50.3 per cent at the same place. The average incidence of virus diseases varied from 64.4 to 94.4 per cent but they have not mentioned the varieties of potato on which the observations were noted. However, in the present case the infestation of rugose mosaic varied from 0.14 to 14.5 per cent and that of leaf roll from 0.14 to 1.7 per cent, depending on the variety and locality.

The incidence of rugose mosaic in Royal Kidney variety was noted in different localities. At Tegri (Hooghly) and Memari (Burdwan) the percentages of infections were 0.1 and 14.5 per cent, respectively. In Darjeeling Red Round the infections were 9.7, 1.05, 5.2 at Sahpur, Gouribati and Kamarkundu (Hooghly) and 7.8 per cent at Daluibazar (Burdwan). Up-To-Date showed no infection at Gouribati (Hooghly), whereas at Memari and Baidyadanga (Burdwan) the infections were 1.8 and 4.9 per cent, respectively.

The incidence of leaf roll infection was not so variable, due to variety and locality as could be determined from the data so far available. The potato variety Royal Kidney had an infection percentage of 0.14 and 1.7 per cent at Tegri (Hooghly) and Memari (Burdwan), respectively. The infection on Darjeeling Red Round at Sahpur, Gouribati and Kamarkundu (Hooghly) were 1.3, 1.0 and 0.6 per cent, respectively, whereas in the same variety the infection was 1.0 per cent at Daluibazar (Burdwan). On the Up-To-Date variety at Memari and Baidyadanga (Burdwan), infections of 0.8 to 1.0 per cent were recorded.

The rate of progress of infection in the case of rugose mosaic gradually rises to attain a maximum value in 1-4 weeks' time, after which there is a fall. There may be subsequent rise in the progress of infections which in exceptional cases, may be followed by further fall and another subsequent rise. In case of leaf roll the infection gradually and steadily progressed with advance in age.

Peak period of infection was generally from one to three weeks after the initial infection, and continued for about two weeks, which was the whole of January in the case of rugose mosaic and from the middle of January to the first week of February in case of leaf roll, depending on the locality and variety. This peak period of infection was followed by a decline in infection. The peak period of infection appears to be correlated with the period of maximum infestation of *M. persicae* which is usually from the last week of January until the the middle of February; Banerjee and Basu (1).

Loss in Yield to Rugose Mosaic and Leaf Roll Infection.

Since so many factors are involved in the reduction of yield it is not possible to estimate the loss in yield directly to these diseases, as consideration must also be given to the time of planting, rate of application and kind of fertilizers, cultural method, climatic conditions and potato variety. Even with these limitations, the data presented merely give an estimation of loss that is possible by methods commonly practiced.

The loss in yield caused by an attack of rugose mosaic and leafroll was determined separately by taking weight of yield of 100 diseased plants of each category as compared with 100 healthy plants selected at random in a particular plot. The weights were taken at the time of normal harvest. The plants from which the yields were taken were marked beforehand.

Data in summarized form are presented in table 2.

TABLE 2.—*Loss in Yield in Different Potato Varieties Due to Rugose Mosaic and Leaf roll.*

Variety	Locality	Yield per 100 Plants in Pound and Per cent Loss in Yield				
		Healthy Pounds	Rugose Mosaic Pounds	Per cent Loss	Leaf Roll Pounds	Per cent Loss
Royal Kidney	Tegri	37.5	12.5	66.6	21.88	41.3
	Memari	75	43.75	41.6	31.25	58.3
Darjeeling Red Round	Sahpur	50	25	50.0	18.75	62.5
	Gouribati	37.5	30	20.0	10	73.3
	Kamarkundu	17.5	7.5	57.1	6.25	64.2
	Daluibazar	110	43.75	60.2	50	54.5
Up-To-Date	Memari	62.5	15	76.0	22.5	64.0
	Baidyadanga	35	25	28.5	18.75	46.4

There is considerable variation in susceptibility to rugose mosaic and leaf roll and reduction in yield amongst the different potato varieties. The loss in yield caused by rugose mosaic varied from 20.0 to 76.0 per cent and that of leaf roll was 41.3 to 73.3 per cent according to variety and locality.

With respect to rugose mosaic infection, the potato variety Royal Kidney suffered a loss of 66.6 per cent at Tegri (Hooghly) and 41.6 per cent at Memari (Burdwan). In Darjeeling Red Round losses were 50.0, 20.0, and 57.1 per cent at Sahpur, Gouribati and Kamarkundu (Hooghly), respectively, whereas at Daluibazar (Burdwan) the loss was 60.2 per cent. The losses recorded in the potato variety Up-To-Date were 76.0 and 28.5 per cent at Memari and Baidyadanga (Burdwan), respectively.

The losses caused by leaf roll were 41.3 and 58.3 per cent in Royal Kidney at Tegri (Hooghly) and Memari (Burdwan), respectively. In Darjeeling Red Round, the losses were 62.5, 73.3, and 64.2 per cent at Sahpur, Gouribati and Kamarkundu (Hooghly), whereas at Daluibazar (Burdwan) the loss was 54.5 per cent. Up-To-Date showed 64.0 and 46.4 per cent loss in yield at Memari and Baidyodanga (Burdwan), respectively.

The reduction in yield caused by rugose mosaic and leaf roll was as high as 72 to 92 per cent and, due to mild mosaic as much as 52 per cent has been recorded by Vasudeva and Azad (5). Vasudeva (4) has also recorded reduction in yield in Phulwa variety from 25.5 to 92.3 per cent negligible mosaic and severe mosaic, respectively. Khanna and Ganguly (3) observed that there was a loss in yield caused by Y virus alone, in Craig's Defiance that varied from 77.5 to 87.5 per cent.

Discussion

The above data give some idea as to the intensity of attack, time of infection, age of the plant at infection, loss in yield, peak period of infection as well as variations to infection due to attack of rugose mosaic and leaf roll virus diseases as prevalent under natural conditions in West Bengal.

From this preliminary survey some inference can be made regarding the effect of locality and period of time on the intensity of attack and loss in yield. It will be found that the variety Royal Kidney had 0.14 per cent infection at Tegri (Hooghly) whereas at Memari (Burdwan) the same variety had 14.5 per cent infection of rugose mosaic. This variation to infection caused by locality is also observed in other potato varieties. In Darjeeling Red Round the percentage of rugose mosaic infection was 9.7 per cent at Sahpur (Hooghly) whereas infection was reduced to 1.05 per cent at Gouribati (Hooghly). Up-To-Date showed a percentage of infection of rugose mosaic of 1.8 and 4.9 at Memari and Baidyadanga (Burdwan), respectively. Whereas, the infection of leaf roll on different varieties of potato in different localities is not marked. This gives an idea regarding the possible existence of areas in these localities where the rugose mosaic incidence may be comparatively low and these areas may be used for the intensive cultivation of potatoes, particularly seed potatoes. Similarly, it may be possible to evade the infection by early sowing as early maturity will result in the production of comparatively disease-free tubers, since the disease usually appears from early January onwards and the maximum period of infestation of vectors and the peak period of incidence, take place toward the end of January to the beginning of February. In West Bengal, as a result of early sowing (October) potatoes can be harvested in late December. This aspect also needs further study, particularly from the standpoint of commercial seed production. The loss in yield is quite considerable from both rugose mosaic and leaf roll.

Summary

1. First infection of rugose mosaic and leaf roll on potato has been observed generally by the last week of December until the second week of January, depending upon locality and variety.

2. Peak period of infection is generally from one to three weeks after initial infection which continues for about two weeks.

3. The percentage of infection of rugose mosaic varies from 0.14 to 14.5 per cent and that of leaf roll from 0.14 to 1.7 per cent depending upon locality and variety.

4. Losses in yield, due to the attack of rugose mosaic vary from 20.0 to 76.0 per cent, and that of leaf roll from 41.3 to 73.3 per cent.

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IT PAYS TO BE HIDDEN HUNGER CONSCIOUS

Plants, like people, can suffer from hidden hunger — the period between the time they are in good health and in bad health. This is an insidious time because nothing looks wrong. The plant seems to be healthy — or certainly shows no signs of hunger. And then — almost suddenly, it seems — the plant crosses a point of no return as far as its finest yield and quality are concerned. Outward signs may never show — except in the yield. It's an insidious thing. Hidden Hunger! A problem requiring careful diagnosis and management that is always hunger conscious.

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GROWTH AND NUTRIENT UPTAKE OF RUSSET BURBANK POTATOES[1]

RAY D. JACKSON AND JAY L. HADDOCK[2]

A knowledge of the growth pattern and nutrient uptake of potatoes is essential to a better understanding of the fertility requirements necessary to produce maximum yields of tubers. Studies on growth and nutrient status of plants during various stages of growth show the period during growth that the nutrient uptake rate is a maximum. During this period of maximum nutrient uptake, the supply of readily available nutrients should be adequate to insure maximum yields.

Research on potato growth and nutrition has been extensive (3, 4, 5, 6, 8, 9, 11, 12).[3] The results reported have shown that geographical location and, consequently, length of growing season, fertility status of soil, soil type, potato variety, and other environmental factors have a marked effect on the growth and nutrient uptake of potatoes.

Growth rates have received less attention in the literature. Hawkins (8), in Maine, reported data for growth rates of plants and tubers for seven growth periods. He found the period of highest growth rates for plants between 61 and 70 days after planting, and for tubers between 82 and 91 days.

In this paper, data are presented for weekly growth and nutrient uptake of Russet Burbank potatoes grown on an irrigated calcareous soil at Logan, Utah.

METHODS AND PROCEDURES

Russet Burbank potatoes were grown on a well-drained calcareous (Millville loam) soil in northern Utah in 1954. Soil moisture was maintained at an optimum level by irrigation. Fertilizer was broadcast uniformly at the rate of 80 pounds nitrogen per acre as ammonium sulfate and 44 pounds phosphorus per acre as treble superphosphate.

The usual planting period for Russet Burbank potatoes in this area is from May 10 to 20. The planting date for the 1954 season was June 1, somewhat later than normal. Our usual harvest period is about two weeks after the first killing frost, or from October 5 to 25. The harvest date in 1954 was October 29, 152 days after planting. The average monthly air temperatures (°F) recorded at the weather station at the experimental site were: July, 72.5; August, 68.5; September, 61.2; and October, 49.3. Freezing temperatures occurred at 122-124, 137-139, 143-144, 148-152 days after planting (18).

The experimental area occupied 6,000 square feet. There were 5 plots each 80 x 15 feet in area. Each week, 3 four-foot sections were harvested in each plot. Therefore, 60 feet of row was harvested weekly. Thirteen sampling dates were used—beginning 60 days after planting.

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[2]Soil Scientists, Western Soil and Water Management Research Branch, Soil and Water Conservation Research Division, Agricultural Research Service, USDA, Fort Collins,, Colo., and Logan, Utah, respectively.
[3]Numbers in parentheses refer to literature cited.

Immediately after harvesting, the plants were washed and left to drain for a short time. The plants were then separated into roots, tops and tubers. Because of incomplete root recovery, data are presented for tops and tubers only. The plants were oven-dried to constant weight at 70° C. The tops and tubers were analyzed for total nitrogen by the Kjeldahl method (14), and for phosphorus and potassium by methods outlined by Richards (16). The results of the chemical analyses are reported in table 1 as percentage composition on an oven-dried basis.

TABLE 1.—*Weekly percentage chemical composition (dry weight basis) of Russet Burbank potato tops and tubers, 1945.*

Date	Days After Planting	Nitrogen		Phosphorus		Potassium	
		Tops	Tubers	Tops	Tubers	Tops	Tubers
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
July 29	60	3.88	*	0.277	*	3.80	*
Aug. 5	67	3.90	1.75	0.240	0.223	3.40	2.14
12	74	3.71	1.58	0.207	0.213	3.11	2.14
19	81	3.58	1.38	0.189	0.184	2.91	1.93
26	88	3.41	1.40	0.169	0.174	2.78	1.86
Sept. 2	95	2.95	1.34	0.138	0.163	2.53	1.71
2	102	2.92	1.29	0.138	0.152	2.50	1.59
16	109	2.68	1.26	0.127	0.138	2.07	1.53
23	116	2.44	1.28	0.116	0.131	1.96	1.48
Oct. 1	124	2.30	1.29	0.116	0.143	1.77	1.59
8	131	2.16	1.34	0.117	0.139	1.82	1.40
15	138	2.03	1.27	0.104	0.132	1.14	1.41
29	152	2.20	1.38	0.102	0.137	0.65	1.41

*No sample.

RESULTS AND DISCUSSION

The weekly yields of Russet Burbank potatoes are shown in figure 1. The tops increased in dry weight up to 95 days, decreased slightly, then remained constant until after 124 days, at which time the dry weight increased to the 95-day value. Dry weight of tops decreased slightly from 124 days to harvest time.

Tuber set began at approximately the 60th day. At the end of 67 days, the tubers were of sufficient size to obtain a sample. The dry weight of tubers increased throughout the entire growth period. On the final harvest date, tubers accounted for 78 per cent of the total dry weight of the plant. These tubers yielded 510 bushels per acre, fresh weight.

Daily growth rates, in pounds per acre each day, of tubers and the tops plus tubers, are shown in figure 2. The daily rates shown are averages for weekly intervals and represent average daily rates of growth for the week ending on the sampling date. The rate of growth of the tops can be obtained by taking the difference between the two bars in figure 2. The rate of top growth varied considerably throughout the growth period. At 102, 131, and 152 days, the tops decreased in dry weight, resulting in a negative growth rate. A probable explanation of the negative growth rate of the tops is the translocation of synthesized plant foods from the tops to the tubers. The magnitude of the negative growth rate of the tops was

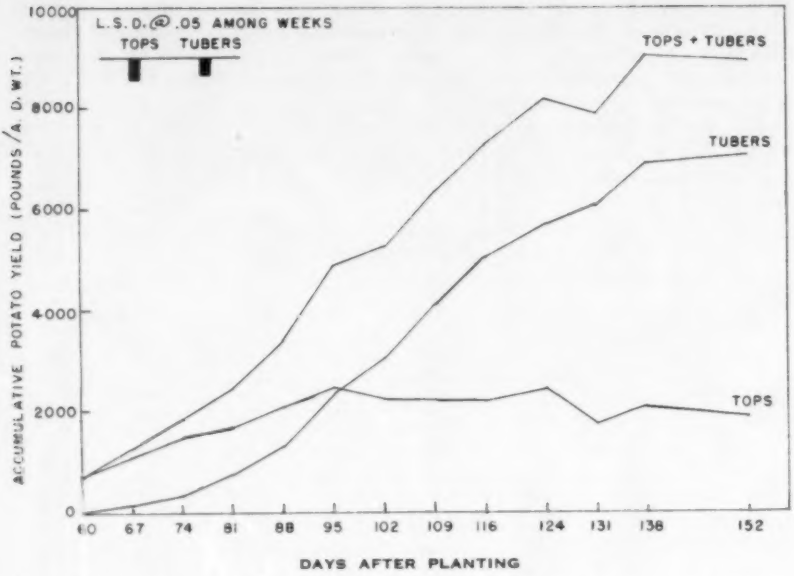

FIGURE 1.—Accumulative weekly yield of Russet Burbank potatoes, 1954.

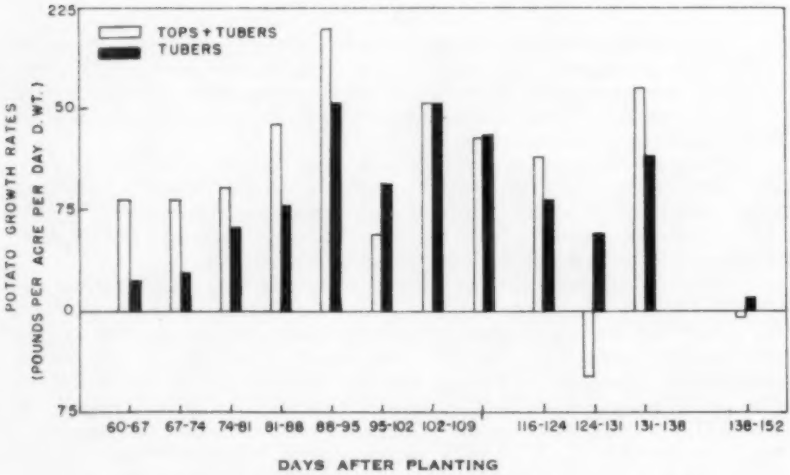

FIGURE 2.—Daily growth rates of Russet Burbank potatoes, 1954.

so large after 131 days that the growth rate for the whole plant was negative. This was probably due to an experimental error in sampling and weighing, although leaf drop may have been responsible for a portion of the loss.

The growth rate of tubers increased very rapidly from 67 to 95 days after planting. During the periods 88-95 and 102-109 days after planting the tubers attained their maximum rate of growth. During these periods, the tubers increased in dry weight at the rate of 154 pounds per acre per day. After the 109th day the growth rate of tubers varied, but always remained positive. It is of interest to note that the tubers had a positive growth rate at the end of 152 days (Final harvest). Since a killing frost occurred after 138 days, this indicates that the tubers continued to grow after a frost, but at a considerably diminished rate (Figures 1 and 2).

Table 1 shows the per cent on a dry-weight basis of nitrogen, phosphorus, and potassium in the tops and tubers at weekly intervals. Generally the percentage of the elements in the tops and tubers decreased throughout the sampling period although some increase can be noted on the later sampling dates.

The accumulative weekly nitrogen, phosphorus, and potassium content is shown in figures 3, 4, and 5. It should be noted that the magnitude of the ordinate in figure 4 is one-tenth that of figures 3 and 5.

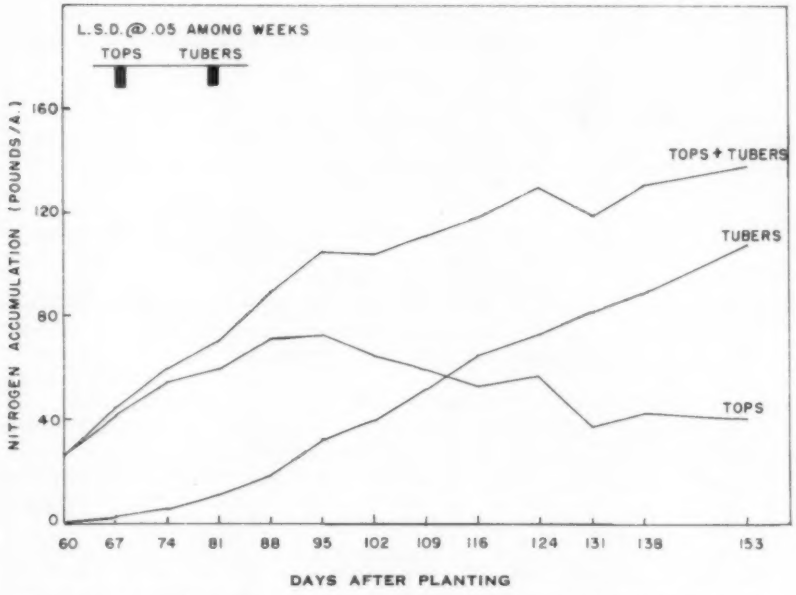

FIGURE 3.—Accumulative weekly nitrogen content of Russet Burbank potatoes, 1954.

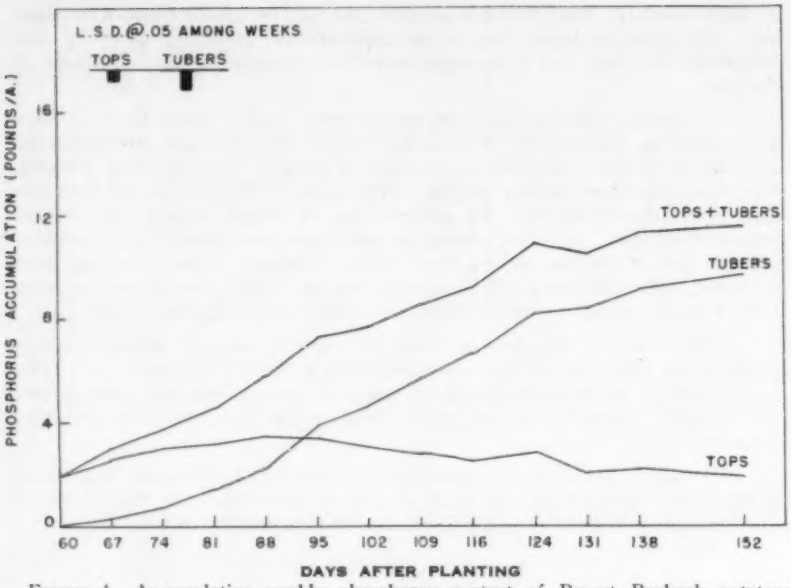

FIGURE 4.—Accumulative weekly phosphorus content of Russet Burbank potatoes, 1954.

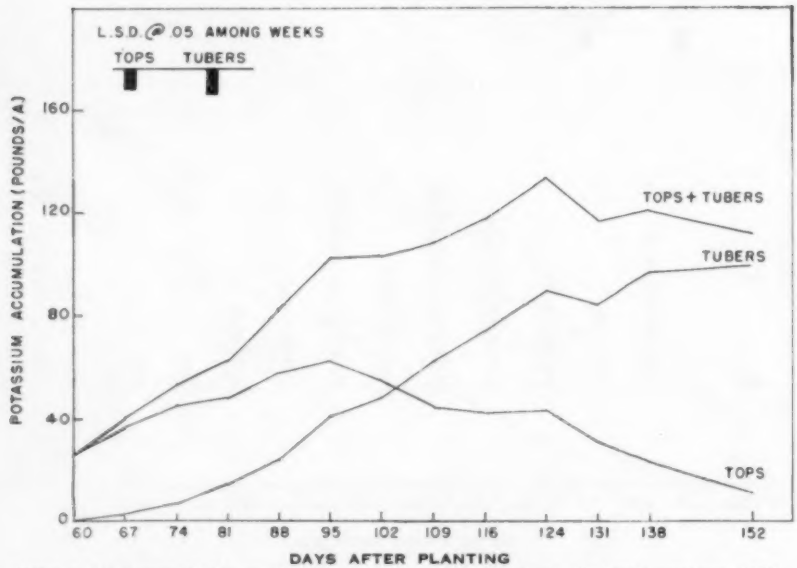

FIGURE 5.—Accumulative weekly potassium content of Russet Burbank potatoes, 1954.

The three elements show essentially the same trend. The tops increased in nutrient content until the 95th day, then decreased throughout the remainder of the growth period. The tops lost about 45 per cent of the nitrogen, and phosphorus, and 80 per cent of the potassium contained at the end of 95 days, during the period 95 to 152 days after planting. The tubers continuously increased in nutrient content throughout the season with the exception of potassium after 131 days. At the end of the season, the tubers accounted for approximately 70 per cent of the nitrogen, 83 of the phosphorus, and 89 per cent of the potassium taken up by the plant. The total nutrient content for this crop of potatoes was 139 pounds of nitrogen, 11.6 pounds phosphorus, and 135 pounds (maximum at 124 days) of potassium per acre. The tubers accounted for 98 pounds of nitrogen, 9.7 pounds of phosphorus, and 100 pounds of potassium per acre.

Because the tops decreased in nitrogen, phosphorus, and potassium after 95 days and the tubers continually increased in these 3 elements, one may conclude that substantial quantities of these 3 elements were translocated from the tops to the tubers, beginning at the 95th day. Translocation of nutrients is well recognized in the literature (1, 2, 3, 8, 13, 15). It should be noted that potassium progressively declined in the total plant after 124 days, but nitrogen and phosphorus did not. This phenomenon has been reported previously (10, 17).

The uptake rate of a particular nutrient for a given period is obtained by taking the slope of the accumulation curve for the nutrient as shown in figures 3, 4, and 5 at the given period. The uptake rate for tubers was the greatest during the period 88-95 days after planting. During this period the tubers absorbed 1.96 pounds of nitrogen, 0.23 pounds of phosphorus, and 2.37 pounds of potassium per acre each day.

Summary

A study was conducted on the growth and nutrient uptake of Russet Burbank potatoes at Logan, Utah. The maximum yield of tops was 95 days, after planting, at which time they composed 49 per cent of the total plant weight. At harvest time the tubers accounted for 78 per cent of the total weight of the plant.

The tubers increased about 147 pounds per acre during a 14-day period after a killing frost.

After the 95th day, the total amount of nutrients contained in the tops decreased continuously. The nutrients increased continuously in the tubers. Apparently nutrients were translocated in substantial quantities from the tops to the tubers beginning at the 95th day and continuing throughout the growth period.

The week 88-95 days after planting was the period during which the maximum rate of absorption of nitrogen, phosphorus, and potassium occurred in the tubers. During this time the tubers absorbed 1.96 pounds nitrogen, 0.23 pounds phosphorus and 2.37 pounds of potassium per acre per day.

This crop of potatoes absorbed 139 pounds of nitrogen, 11.6 pounds of phosphorus, and 135 pounds (124th day) of potassium per acre to produce 510 bushels per acre (fresh weight). The tubers accounted for 98 pounds of the nitrogen, 9.7 pounds of phosphorus, and 100 pounds of potassium taken up by this crop of potatoes.

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NEWS AND REVIEWS

PURPLE TOP HAIR SPROUT AND LOW SOIL TEMPERATURE IN RELATION TO SECONDARY OR SPROUT TUBER FORMATION[1]

R. H. LARSON[2]

Frequently during the past several seasons the writer's attention has been called to nonemerging potato hills or the failure of potato seed pieces to produce an emerging plant. In many early planted potato fields observed, especially in the Racine-Kenosha area of Wisconsin, the lack of stand or nonemergence ranged from 4 to 9 per cent. When the no-sprout hills were dug, it was found that the seed pieces were firm, with well-developed, small secondary tubers growing directly from the eye (Figure 1, A). After planting these firm field seed pieces in a warm soil in the greenhouse, weak, spindly hair sprout plants developed without the formation of sprout tubers.[3]

A combination of factors not reported as causing sprout tubers in potatoes was observed during soil temperature studies, under controlled conditions in the greenhouse at Madison, in relation to the sprouting of hair sprout tubers collected from aster yellows (purple top) infected Sebago. It was found that in a low temperature dark chamber at 12° C., a large percentage of spindle sprout tubers produced small secondary tubers at the end of a very short sprout; whereas, in a high temperature dark chamber at 28° C., weak or spindle sprouts were produced (Figure 1, B). Likewise, when hair sprout tubers were planted in a cold soil held at about 12° C., secondary sprout tubers were also formed; and in a warm soil held at about 28° C., weak, hair sprout spindle plants developed as shown in figure 2.

Growers planting very early in the season in cold soil are advised to move their seed stocks to medium warm storage (68° to 72° F.) for a period of 10 days to 2 weeks before planting to induce slight sprouting. All multiple sprout tubers and weak or hair sprout tubers can thus be eliminated, reducing to a large extent the amount that would normally be planted. The planting of normal sprouted seed pieces or number two whole tubers will reduce the yield loss due to weak or nonemerging hills.

[1]Accepted for publication May 5, 1958.

[2]University of Wisconsin, Department of Plant Pathology, and Crops Research Division, ARS, USDA, Madison, Wis.

[3]Davidson, T. M. W. 1958. Dormancy in the potato tuber and the effects of storage conditions on initial sprouting and on subsequent sprout growth. Amer. Potato Jour. 35 : 451-465.

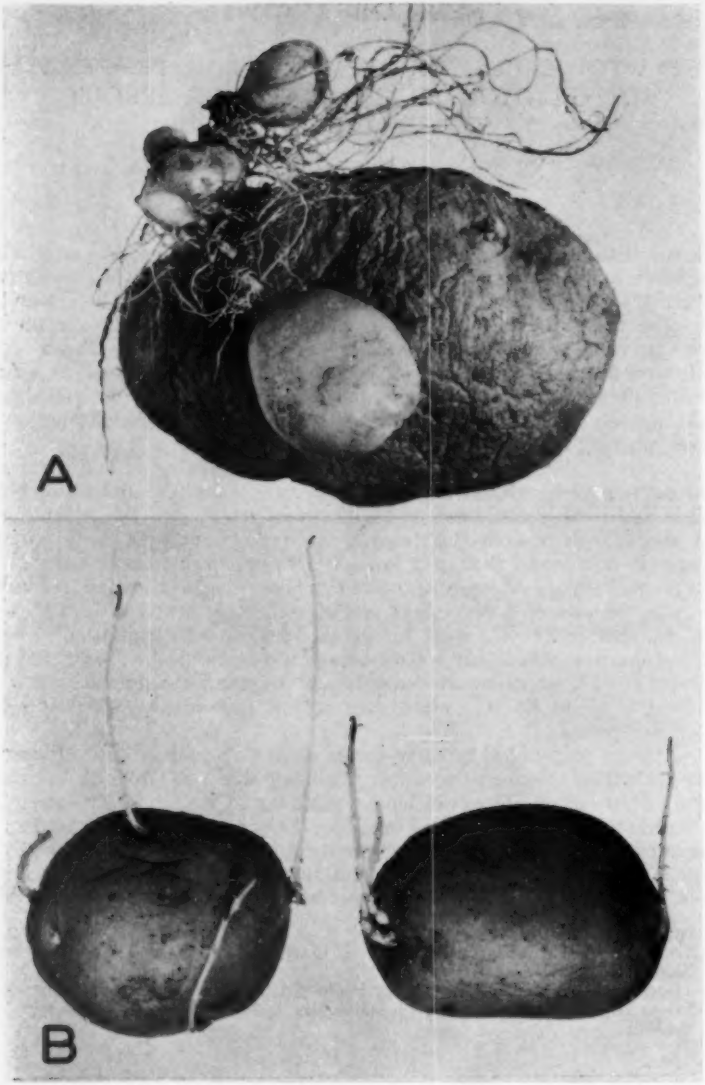

FIGURE 1.—A, Potato seed piece dug from a non-emerging hill in the field showing secondary tuber development. Seed pieces of this type, when placed in a warm chamber or planted in warm soil, produce weak hair-sprouts. B, Sebago hair-sprout tubers selected from purple top plants. Note the spindly hairlike sprout produced in a warm dark storage.

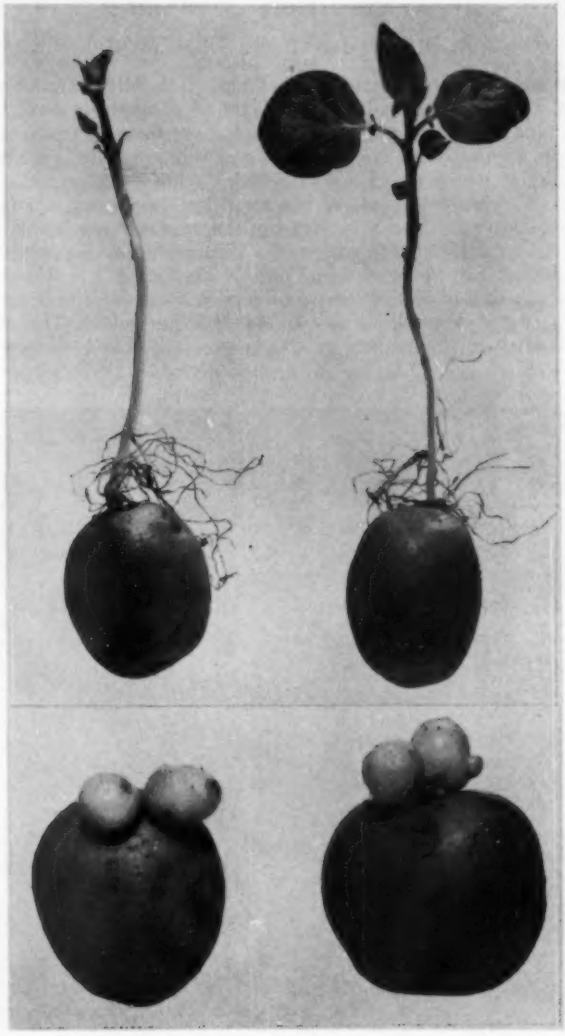

FIGURE 2.—Germination of hair-sprout tubers. Upper, production of weak hair-sprout plants in warm soil (28° C.). Lower, production of secondary or sprout tubers in cold soil (12° C.).

SPROUT INHIBITION OF BULK STORED POTATOES[1]

N. R. THOMPSON AND D. R. ISLEIB[2]

Fluctuations of the potato market and variability of marketing conditions make it desirable to hold some lots of potatoes beyond the normal storage period. Sprouting then becomes a problem. Advance planning permit applications of maleic hydrazide (2) during the growing season, but this destroys the seed value of "B" size potatoes. Recommended dusts or dips (4, 5) before the tubers enter storage are quite satisfactory, but few growers desire to add an extra operation when machinery and labor are taxed to capacity. Such treatments depend upon vaporization of the applied material for absorption to inhibit sprouting (1, 3). A practical method of vaporizing the sprout inhibitor would simplify treatment and enhance the value of potatoes late in the storage period. The opportunity to attempt such a procedure on a commercial scale presented itself in April of 1957.

FIGURE 1—Plastic partition used to confine the vapor of methyl ester of naphthaleneacetic acid

[1]Accepted for publication May 21, 1958.
Journal Article Number 2256

[2]Associate and Assistant Professor, respectively, Dept. of Farm Crops, Michigan State University, East Lansing, Mich.; Michigan Agricultural Experiment Station, East Lansing, Mich.

A potato grower had contracted to supply sound, sprout-free potatoes through the month of June and requested assistance in the application of a sprout inhibitor. The potatoes were stored in an insulated storage dependent upon cool outside air to maintain the desired temperatures. At this time of year outside air temperatures were not low enough to maintain storage temperatures that prohibit sprouting. The storage temperature had risen to 48° F. and the potatoes had commenced to sprout.

The storage was 50′ x 200′ and contained no divisions. The air circulation system forced air through a walk-in tunnel the full length of one side of the building. Lateral outlets and ducts at floor level crossed the storage to distribute air through the potatoes.

Ten thousand bushels of Katahdin potatoes were stored in one end of the storage. Plastic sheets were used to partition the storage and the air tunnel so that the vaporized inhibitor would be concentrated in the air surrounding the potatoes as shown in figure 1. When the fans were turned on aerometers showed good movement of air throughout the potato pile. On May 8, three and one half gallons of 36.4 per cent methyl ester of naphthaleneacetic acid were sprayed into the lateral air ducts and the walk-in tunnel with the circulating fans in operation. The resistance to air movement through the potatoes tended to create a low pressure area above the potatoes so that the plastic partition was subjected to no outward pressure.

FIGURE 2.—Sprout growth on potatoes, untreated and treated with the vapor of methyl ester of naphthaleneacetic acid.

Samples were collected at random from the bin before and after treatment. The samples were stored at 60° F. for 37 days. Sprout growth was satisfactorily inhibited (Figure 2). Potatoes were delivered in acceptable condition the first week of July. For the institutional trade, the peeling performance or culinary quality of these potatoes made them more acceptable than new potatoes available on the market at that time.

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LIST OF INTERNATIONAL POTATO RESEARCH PROJECTS

(Continued from December 1958 issue)

GERMAN FEDERAL REPUBLIC

MAX-PLANCK-INSTITUTE, KOELN-VOGELSANG, GERMAN FEDERAL REPUBLIC

M. L. Baerecke

VIRUS DISEASES — Leaf roll—resistance, vectors, strains, staining methods of necroses.

N. O. Frandsen

FUNGUS DISEASES — Late blight—strains; field resistance - hypersensitivity.
Scab—resistance; testing methods.
Wart—resistance; new strains.

Hans Ross

BREEDING — Resistance to virus A, X, Y.
NEMATODES — (*Heterodera rostochiensis*)—resistance.
TAXONOMY — Species collection.
VIRUS DISEASES — Virus A, X, Y—resistance; strains.
Virus S—properties, hosts.
Tobacco ringspot on potatoes—properties, hosts.

W. Rudorf

BREEDING — Inbreeding of clones with special resistance to late blight, wart, virus. Combination of inbred clones. Combination resistance (fungus, virus) and quality.

H. von Wangenheim

TAXONOMY — Cytogenetics, embryology, species hybridization.

MAX-PLANCK-INSTITUTE, ZWEIGSTELLE ROSENHOF, LADENBURG/NECKAR, GERMAN FEDERAL REPUBLIC

M. Torka

BREEDING — Resistance to *Leptinotarsa decemlineata.*
INSECTS — *Leptinotarsa decemlineata*—biology, testing methods, resistance.

RAGIS-ZUCHTSTATION HEIDEHOF, BROCKHOFE 20A, KREIS UELZEN, GERMAN FEDERAL REPUBLIC

W. Feistritzer and Gunther Wriedt

INSECTS — Resistance to potato eelworm (*Heterodera rostochiensis*)
BREEDING — Inbreeding.

RHEIN.-FRIEDRICH-WILHELM-UNIVERSITAET, PLANT PATHOLOGY AND ETNOMOLOGY, BONN/RH. GERMAN FEDERAL REPUBLIC

H. Blunck

INSECTS — Aphids as virus vectors; aphid populations.

H. Braun

FUNGUS DISEASES — *Phoma, Phytophthora, Synchytrium.*

GREECE

AGRICULTURAL COLLEGE OF ATHENS, PLANT PATHOLOGY LABORATORY, BOTANICAL GARDEN, ATHENS, GREECE

C. Catsimbas

BACTERIAL DISEASES — Bacterial ring rot.
FUNGUS DISEASES — Late blight.
NEMATODES — Golden nematode.
NONPARASITIC DISEASES — Internal rust spot.
VIRUS DISEASES — Leaf roll virus, virus Y, A, X.

IRELAND

ALBERT AGRICULTURAL COLLEGE, BALLYMUN ROAD, DUBLIN, IRELAND

J. Duggan

NEMATODES — Golden nematode (*Heterodera rostochiensis*)—examination of soil and plant samples to keep the status and distribution of the pest in the seed-potato districts.
Population studies using different potato varieties.
Population studies using non-host crops.
Cultural methods of control.
Studies on hatching of cyst contents and factors which affect it.
Resistance.

DEPARTMENT OF PLANT PATHOLOGY

James B. Loughnane and Jean McKay

VIRUS DISEASES — Virus A—hosts.
Virus M—properties, serology, strains, hosts, indicator plants.
Virus S—properties, serology, strains, indicator plants, resistance, effects on yield, alone and in combination with other viruses — survey of occurrence in Ireland.
Virus X—strains, serology.
Virus Y—strains.
Paracrinkle—studies on a tuber necrosis caused by grafting with variety King Edward.
Leaf roll virus—effects on yield, studies on spread under field conditions.
Spraing—varietal susceptibility, transmission, soil infection.
General—effects on yield of individual viruses and virus combinations, varietal reactions to combinations of viruses: study of a tuber necrosis occurring in variety Golden Wonder.
NONPARASITIC DISEASES — Internal tuber necrosis—studies on possible causes.
Skin necrosis—studies on possible causes.
FUNGUS DISEASES — Late blight—conditions affecting spread, control.
Pink rot—study of haustoria in potato tubers.

ITALY

MINISTERO DELL'AGRICOLTURA E DELLE FORESTE, STAZIONE DI PATOLOGIA VEGETALE, ROME, ITALY

Roberto Gigante and Aiuto Direttore

FUNGUS DISEASES
NONPARASITIC DISEASES
VIRUS DISEASES
} Determination and study of the diseases of economic importance.

Osvaldo Lovisolo
VIRUS DISEASES — Strains of virus X, potato aucuba mosaic; virus vectors

UNIVERSITA-PERUGIA, INSTITUTO DI PATOLOGIA VEGETALE, FACOLTA DI AGRARIA, PERUGIA, ITALY
C. Sempio and M. D'Armini
VIRUS DISEASES — Virus disease study by mechanical inoculation to test plants.
Study of symptoms induced by leaf roll, A, M, S, X, Y viruses.
Attempt at virus transmission with *Acheta campestris* and *Leptinotarsa decemlineata*.

THE NETHERLANDS

AGRICULTURAL UNIVERSITY, WAGENINGEN, THE NETHERLANDS
ENTOMOLOGICAL LABORATORY
D. Stegwee — Biochemical work on virus metabolism in aphids.
J. de Wilde — Physiology of diapause and reproduction in the Colorado beetle.

EXPERIMENT STATION FOR FIELD CROP AND GRASSLAND HUSBANDRY
A. J. Reestman and D. E. van der Zaag — General problems on potato culture.

FOUNDATION FOR AGRICULTURAL PLANT BREEDING
C. A. Huysman — Breeding, *Heterodera rostochiensis* resistance.
G. A. Thijn — Breeding.
H. T. Wiersema — Breeding, virus resistance.

GENERAL NETHERLANDS INSPECTION SERVICE FOR SEEDS OF FIELD CROPS AND FOR SEED POTATOES (N. A. K.)
J. Hiddema — Potato certification and clonal selection problems.

INSTITUTE OF AGRICULTURAL PLANT BREEDING
H. J. Toxopeus, B. Maris, H. H. Schnieders — Investigations into disease resistance in potatoes.

INSTITUTE FOR BIOLOGICAL AND CHEMICAL RESEARCH ON FIELD CROPS
K. B. A. Bodlaender — Physiology and ecology of potatoes.
Miss N. Krijthe — Tuber development of potatoes.
C. Lugt — Quality of potatoes.

INSTITUTE FOR PHYTOPATHOLOGICAL RESEARCH, (I. P. O.), BINNENHAVEN 4A
FUNGUS DISEASES
J. H. van Emden — Rhizoctonia and scab.
R. E. Labruyere — Scab.
J. C. Mooi — Dry rot and other tuber diseases.
VIRUS DISEASES
A. B. R. Beemster — Transport of potato viruses within the plant in connection with the time of harvest.
J. C. s'Jacob — Research on disease resistance.
H. den Ouden — Control of the potato root eelworm.
Miss F. Quak — Investigations on the therapy of virus diseases.
J. W. Seinhorst — Nematodes.
J. H. Venekamp — Biochemiacl virus research.
J. P. H. van der Want — Stem mottle virus.

INSTITUTE FOR POTATO STORAGE
W. H. de Jong and co-workers — Potato storage problems; influence of growing conditions on keeping quality; application of chemical sprout depressants; studies on mechanical damage and tuber diseases.

LABORATORY OF FIELD CROP HUSBANDRY
W. J. Dewez and co-workers — Culture of seed potatoes and climatic research on potatoes.

LABORATORY OF PHYTOPATHOLOGY

Miss J. Oortwijn Botjes — Chemical diagnosis of potato virus diseases.

A. P. Kole — Archimycetes.

M. Oostenbrink — Nematodes (taxonomy, population dynamics and resistance).

A. Rozendaal — General potato virus problems; resistance experiments in connection with viruses A, F, M, S, X, Y, leaf roll, stem mottle and their strains. Determination of hosts and different properties. Premunity tests.

LABORATORY OF PLANT PHYSIOLOGY

J. L. Verhoeks — Physiology of leaf roll diseased plants.

E. C. Wassink and co-workers — Metabolism of potatoes.

LABORATORY OF VIROLOGY

J. Dijkstra — Corky ringspot.

H. W. J. Ragetli — Chemical diagnosis; paper chromatography.

T. H. Thung and co-workers — Research on various aspects of viruses and virus diseases, especially on those of a fundamental importance.

PLANT PROTECTION SERVICE, WAGENINGEN

C. J. Briejer and co-workers — Supervision of the execution of control measures against the potato root eelworm. Research on susceptibility to wart disease and root nematodes.

H. Hietbrink — Potato root eelworm and black scab.

H. A. Ormel and M. M. de Lint — Potato diseases in general; haulm killing.

INSTITUTE FOR RESEARCH ON VARIETIES OF FIELD CROPS, BENNEKOM

J. A. Hogen Esch and co-workers — Testing of new potato varieties.

NATIONAL COUNCIL FOR APPLIED SCIENTIFIC RESEARCH IN THE NETHERLANDS (T.N.O.), BENNEKOM

D. Hille Ris Lambers — Potato aphid investigations.

LABORATORY OF BULB RESEARCH, LISSE

D. H. M. van Slogteren, E. van Slogteren, and Miss M. C. Cremer

VIRUS DISEASES — a) General diagnostic serological methods and their development for use in practice.

b) Serology of potato viruses X, Y, S, G and a new virus (M).

c) Stem mottle, apart from the potato, its connection with the presence of the causal virus in other hosts.

POTATO TRIAL FARM, OOSTWOLD

A. H. Muntinga — Species collection; testing new potato seedling.

PLANT BREEDING STATION CENTRAAL BUREAU, HOOFDDORP, THE NETHERLANDS

C. Mastenbroek

BREEDING — Resistance to late blight, golden nematode, frost, virus diseases (leaf roll, X, A, Y), wart.

FUNGUS DISEASES — Differentiation of late blight races.

UNIVERSITY OF AMSTERDAM, ENTOMOLOGICAL LABORATORY, AMSTERDAM

P. A. van der Laan — Biology of *Heterodera rostochiensis*.

NORWAY

NORWEGIAN PLANT PROTECTION INSTITUTE, DIVISION OF PLANT PATHOLOGY, BOTANICAL MUSEUM, OSLO 45, NORWAY

Erling Forsund

FUNGUS DISEASES — Late blight—resistance, occurrence and distribution of biological races; heat-resistance and late blight resistance. Production of late blight-free potato seed in isolated fields (with Egil Oyjord).

Late blight warning service—in a regular warning service attention will be paid to the use of long range weather forecasts in the prognosis of late blight warnings.

POLAND

AGRICULTURAL SCHOOL, INSTITUTE OF PHYTOPATHOLOGY, POZNA'N, UL. WOJSKA POLSKIEGO 71C, POLAND

W. Blaszczak, and Z. Sosna

FUNGUS DISEASES — Studies on susceptibility of potato varieties to *Rhizoctonia solani* Kuehn. Studies on common potato scab *Actinomyces* sp. Pathogenicity of strains, varietal susceptibility.

K. Zaleski, W. Blaszczak, and Z. Sosna

VIRUS DISEASES — Studies on susceptibility of potato varieties to virus diseases.

INSTITUTE OF PLANT PROTECTION, POZNA'N, UL. MICZURINA 1, KOLO JUNIKOWA, POLAND

W. Wegarek

INSECTS — Colorado beetle and its control/catch belt method, conditions of winter-conservation, field and experimental ecology. Vitamins and some organic compositions in potato leaves on development of Colorado beetle. Digestion enzymes and metabolism of Colorado beetle. Influence of microclimate and biotical factors on Colorado beetle population. Mechanics and iniection conditions with Colorado beetle. The effect of HCH, Chlordane and dieldrin preparations as soil disinfectants.

NEMATODES — Control of potato-nematode by means of sanitary and chemical methods. Fauna of Polish nematodes. Designation of their rejonization in the regions of Poznan. Influence of root exudates of some cultural plants on exit of potato-nematode-larvas from the galls.

SCHOOL OF AGRICULTURE, BOTANICAL INSTITUT, PLANT PATHTOLOGY, AL. MICKIEWICZA 21, CRACOW, POLAND

M. Dwurazna

PHYSIOLOGY — Respiration of healthy and degenerated potatoes.

Aniela Kozlowska

VIRUS DISEASES — 1) Viruses X, S and Y—properties, strains, resistance.
2) Serological methods—precipitation and complement fixation test.
3) The ultraviolet light methods in detection of latent strains of virus X.
4) The influence of climate on the virus diseases in potatoes.
5) The conductmetrical method in virus research.
6) Inhibition problems—influence of cysteine, ascorbic acid, lybdenum.

K. A. Miczynski

VIRUS DISEASES — Influence of ultrasonic on virus X.
Chromatrographic methods—amino acids.

INSTITUTE OF BREEDING AND ACCLIMATIZATION OF PLANTS, LABORATORY OF WART DISEASE OF POTATOES, BYDGOSZCZ, PL. WEYSSENHOFFA 11, POLSKA - POLAND

Pawel Leszczenko

FUNGUS DISEASES — Resistance to wart (*Synchytrium endobioticum*), concerning license for growing new varieties from Polish breeding institutions. Searching after new strains (biotypes) of potato wart. Resistance to *Rhizoctonia*.

INSTITUTE OF PLANT PROTECTION, LABORATORY FOR CONTROL OF PESTS AND DISEASES BY CULTURAL (SANITARY) MEASURES, BYDGOSZCZ, PL. WEYSSEHOFFA 11, POLSKA-POLAND

NEMATODES — Biology and control of potato nematodes (*Heterodera rostochiensis*) by sanitary measures (crop rotation, early crop, manuring, pregermination, time of harvest, soil type).
Chemical control of (*Heterodera rostochiensis*) in separate division cal. Helminthological Laboratory.

SPAIN

ESTACION DE FITOPATOLOGIA AGRICOLA, APARTADO 10, LA CORUNA, SPAIN

J. R. Sardina

VIRUS DISEASES — Leaf roll virus—hosts, strains, histology, spread, resistance.
In collaboration with: A. G. Orad and F. P. de San Roman, Estacion de Mejora de la Patata, Pasco de la Senda-3-, Vitoria, Spain.

ESTACION DE HORTICULTURA; CALLE DE LUIS BRAILLE, 1, BENICALAP, VALENCIA, SPAIN

G. Lopez Campos
BREEDING — Genetics, drought resistance.

ESTACION DE MEJORA DE LA PATATA-SENDA, 3-VITORIA-ESPANA

A. G. Orad
INSECTS — Virus vectors—populations and spread of virus.
VIRUS DISEASES — Leaf roll virus—spread, tolerance and resistance, diagnosis.
Virus Y—properties, spread, tolerance and resistance, strains.
Virus A—spread, strains, diagnosis.
Spindling sprout—conditions, infectivity.

A. Sanudo Palazuelos
TAXONOMY — Species collections, species hybridization, cytogenetics. Crossability of Cardiophylla and Pinnatisecta Series.

F. P. San Roman
NONPARASITIC DISEASES — Spindling sprout—conditions.
VIRUS DISEASES — Leaf roll virus—spread, diagnosis.
Virus Y—properties, spread.
Virus X—symtomatologie, spread, serologie, strains.
Virus Aucuba—spread, effects on crop, strains.

A. Zubeldia
BREEDING — Genetics, earliness.

MISION BIOLOGICA DE GALICIA, PONTEVEDRA, SPAIN

J. L. Blanco
BREEDING — Genetics, frost resistance.

SWEDEN

INSTITUTE FOR PLANT RESEARCH AND COLD STORAGE (IVK), NYNASHAMN, SWEDEN

Lennart Carlstrom
BACTERIAL DISEASES — Blackleg—causal organisms, mode of dissemination, control by antibiotics.

Borje Emilsson
FUNGUS DISEASES — Late blight—techniques for preventive spraying, including aerial spraying.
VIRUS DISEASES — Virus Y and leaf roll virus—rate of spread in different parts of Sweden.
STORAGE — Influence of various factors on weight losses during storage.

Borje Emilsson and Harold Fernholm
Pregermination of seed potatoes in artificial light.

Borje Emilsson and Nils Gustafsson
BREEDING — Spontaneous aberrant types.
FUNGUS DISEASES — Common scab—control by soil treatment with fungicides.
VIRUS DISEASES — Virus Y and leaf roll virus—varietal resistance.
Virus X and virus S—influence on yield.
CULTURAL TECHNIQUE — Influence on the maturity of seed tubers on yield, etc.
Effect of treating seed tubers with thiourea on number of stems and tubers per hill, yield, etc.

Nils Gustafsson
FUNGUS DISEASES — Late blight—control by mechanical and chemical methods of haulm-killing.
Common scab—varietal resistance.
CULTURAL TECHNIQUE — Influence of seed tuber size and spacing on yield, etc.

Aage Heiken
BREEDING — X-ray induced mutations.
Spontaneous aberrant types—frequency taxonomy.

INSTITUTIONEN FOR VAXTSJUKDOMSLARA, UPPSALA 7, SWEDEN
Karl Bjorling
FUNGUS DISEASES — Late blight—field control (volume and pressure, droplet size, etc.) With B. Emilsson, Nynashamn, Sweden.
VIRUS DISEASES — Aphid species in relation to virus-transmitting ability.

SWEDISH SEED ASSOCIATION, DEPARTMENT OF POTATO BREEDING, SVALOF, SWEDEN
Olof Tedin
QUALITY — The production of new varieties of table potatoes with high quality and yield and varieties for industrial purposes with high starch content and yield.
Daniel Lihnell
BREEDING — Attention is paid only to wart immune clones. Immunity tests are carried out at the Plant Pathological Institute, Stockholm 19.
Special attention is paid to resistance to the following diseases: Late blight, scab, nematodes and viruses (X, Y and leaf roll).
Thore Denward
FUNGUS DISEASES — *Phytophthora*—variability of bio-types.
V. Umaerus
Field resistance to late blight in *Solanum tuberosum* and different wild species at the Plant Pathological Institute, Stockholm 19, Sweden.
PHYSIOLOGY — Certain selection series are being worked up under extreme long day conditions at the Lulea branch station close to the Arctic Circle.

SWEDISH STATE PLANT PROTECTION INSTITUTE, STOCKHOLM 19, SWEDEN
O. Ahlberg
NEMATODES — Golden nematode—cultural methods, distribution, control.
D. Lihnell
FUNGUS DISEASES — Late blight—varietal resistance.
VIRUS DISEASES — "Spraing mosaic"—varietal resistance, symptoms, host range, transmission, properties.

SWEDISH STATE PLANT PROTECTION INSTITUTE, BRANCH STATION AT AKARP, AKARP, SWEDEN
L. Nilsson
BACTERIAL DISEASES — Blackleg (*Erwinia sp.*), infection ways, strains.
Ring rot (*Corynebacterium sepedonicum*)—control, varietal susceptibility.

SWITZERLAND

EIDG. LANDW. VERSUCHSANSTALT, STAZIONE FEDERALE D' ESPERIENZE AGRARIE, ZURICH-OERLIKON, SWITZERLAND
E. R. Keller
FUNGUS DISEASES — Early and late blight, rhizoctonia and scab resistance in variety field trials.
PHYSIOLOGY — Tissue culture, variety "Weltwunder" X-carrier.
QUALITY — Cooking and eating quality (variety trials).
VIRUS DISEASES — Production of virus-free seed potatoes, virus infection in relation to early harvest and haulm killing and resistance.
Organization of seed certification (German and Italian speaking part of Switzerland)
Investigations of the suitability of different regions for seed production.
Pre-sale testing of seed production by Igel-Lange-Test.
W. Meier
INSECTS — Aphid investigations—systematics, ecology, foreecasting of aphid development and flight.
VIRUS DISEASES — Leaf roll—host range.
H. Zogg
FUNGUS DISEASES — Investigations with different fungicides.

FEDERAL AGRICULTURAL EXPERIMENTAL STATIONS, LAUSANNE, AND FIELD STATION AT CHANGINS/NYON, SWITZERLAND

DEPARTMENT OF PLANT PROTECTION

M. Staehelin

FUNGUS DISEASES — Late blight warning service, *Phoma* species, chemical control of scab.

DEPARTMENT OF VIROLOGY

J. Munster

Study of the behavior of new European varieties — in collaboration with the Swiss Association for Experimentation and Supply in potato seed. Virus resistance and hypersensitivity, resistance to downy mildew, *Alternaria solani*, *Streptomyces* sp., *Rhizoctonia solani*, yield and cooking quality. Factors influencing tuberization.

INSECTS — Vectors—study of the evolution of aphids in order to determine:

a) date of destruction of the tops for seed production and

b) systemic insecticides for aphid control.

VIRUS DISEASES — a) Control measures such as pregermination, time of roguing, influence of primary infections and symptoms, control of aphids and early destruction of plant tops.

b) Diagnostic methods for viruses: serology, tuber indexing, histological tests (Igel-Lange).

c) Spindling sprout—relation to Stolbur virus.

U.S.S.R.

ACADEMY OF AGRICULTURAL SCIENCES, INSTITUTE OF PLANT PROTECTION, PHYTOPATHOLOGY, GERTSEN 42, LENINGRAD, U.S.S.R.

K. M. Stepanov

FUNGUS DISEASES — Late blight—forecasting methods in relation to practical application of field control.

N. A. Naumov

FUNGUS DISEASES — Monographic summary of world literature on late blight of potatoes.

T. I. Fedotov and N. N. Kozhevnikov

FUNGUS DISEASES — Late blight—stability of strain found in the U.S.S.R. Resistance in varieties and hybrids.

T. V. Stepanov

FUNGUS DISEASES — Late blight—biochemical properties of strains.

S. M Tupenvich

FUNGUS DISEASES — Late blight—biology of strains, changes in resistance, environment in relation to disease development, agrotechnical measures and disease development.

Rhizoctonia—epidemiology, biology of the fungus, agrotechnical control measures.

Z. S. Kasperovich

FUNGUS DISEASES — Wart—ecological studies.

T. I. Fedotov

FUNGUS DISEASES — Wart—resistance.

T. I. Fedotov, V. V. Shopin, and V. I. Sadovinikov

VIRUS DISEASES — Viruses A, X, and Y—resistance in varieties and hybrids.

ACADEMY SCIENCES, INSTITUTE OF GENETICS, MOSCOW, U.S.S.R.

K. S. Sukhov

VIRUS DISEASES — Virus X mutation in combination with other potato viruses.

BOTANICAL GARDEN, LENINGRAD, U.S.S.R.

N. A. Lebedeva

BREEDING — Genetics—polyploidy of the potato.

INSTITUTE OF PLANT INDUSTRY, TUBER BEARING PLANTS DEPARTMENT, GERZEN 44, LENINGRAD, U.S.S.R.

S. M. Bukasov
BREEDING — Disease and insect resistance.
TAXONOMY — Species and varieties collections, species hybridization.

P. G. Chesnokov
INSECTS — Virus vectors.
VIRUS DISEASES.

A. J. Kameras
BREEDING — Disease resistance.

W. S. Lechnovicz
TAXONOMY.

V. I. Rasumov
PHYSIOLOGY — Tuberization, photoperiod.

A. I. Rudenko
Agrometeorological investigation of the potato.

MOSCOW UNIVERSITY, PLANT PATHOLOGY, LENIN HILLS, MOSCOW V-234, U.S.S.R.

M. V. Gorlenko
BACTERIAL DISEASES — Blackleg, soft rot.

POTATO WART RESEARCH STATION, SADOVAYA 32, LENINGRAD, U.S.S.R.

N. N. Vladimerskaya
FUNGUS DISEASES — Wart—new chemical preparations in relation to the genetic element.

Mme. N. N. Vladimirskaya
FUNGUS DISEASES — Potato wart—cyst germination, field control.

POTATO WART LABORATORY, ROSE LUXENBURY 2ND LANE, 5-A, MINSK, BELORUSSIAN, SSR.

C. S. Gandelman
FUNGUS DISEASES — Wart—agritechnical control measures.

POTATO WART LABORATORY, FEDKOVICH 42, CHERNOUITS, UKRAINIAN, SSR.

P. I. Yakolelov
FUNGUS DISEASES — Wart—biology.

SOUTH AMERICA

ARGENTINA

ESTACION EXPERIMENTAL AGRICOLA, BALCARCE, ARGENTINA, SOUTH AMERICA

DEPARTMENT OF GENETICS

Domingo R. Pasquale and Oscar A. Garay
BREEDING — Selection of varieties.

Cesar Juan Induni
BREEDING — QUALITY — TAXONOMY.

DEPARTMENT OF PLANT PATHOLOGY

Atilio V. Calderoni
FUNGUS DISEASES — Fusarium and scab resistance; late blight—races and resistance.
VIRUS DISEASES — Virus X, Y, and leaf roll, resistance.

DEPARTMENT OF PLANT PHYSIOLOGY

Pedro Garese
PHYSIOLOGY AND UTILIZATION.

INSTITUTO DE SANIDAD VEGETAL, PASEO COLON 922, 4° PISO, BUENOS AIRES, ARGENTINA

Amalia F. Moreno
NEMATODES — Root-knot—bioecologic study of the nematode *Meloidogyne incognita* and *M. incognita* var. *acrita* on potato plantations. Varieties that can be considered as resistant in the region of Buenos Aires.

LABORATORIO DE FITOPATOLOGIA DEL DELTA DEL PARANA, CAMPANA (BUENOS AIRES), ARGENTINA
M. V. Fernandez Valiela
VIRUS DISEASES — Leaf roll—Lycopersicum virus 3.

BRAZIL

ESCRITORIO TECNICO DE AGRICULTURA, AVENIDA GENERAL JUSTO 171 - 7° andar, RIO DE JANEIRO, BRAZIL
Josue A. Deslandes
BACTERIAL DISEASES — "Murchadeira" (*Pseudomonas solanaccarum*)—races and hosts, sources of resistance, persistence of the pathogen in the soil, symptomless infection, seed treatment, and antibiotics.
FUNGUS DISEASES — *"Rhizoctonia solani"*—epiphytology, pathogenicity, root rot, and other symptoms, soil desinfestation.

INSTITUTO AGRONOMICO DO SUL PELOTAS, RIO GRANDE DO SUL, BRAZIL
Delorge Mota da Costa
BREEDING — *Phytophthora infestans.*
FUNGUS DISEASES — *Phytophthora infestans* strains.
Research projects: Regional variety tests, irrigation, fertilizers.
Manoel Alves de Oliveira
FUNGUS DISEASES — Chemical control.

INSTITUTO BIOLOGICO, SAO PAULO, BRAZIL
Karl M. Silberschmidt
VIRUS DISEASES — Survey of viruses occurring in potato.
Virus Y—strains.
Theoretical and practical value of cross-protection tests with viruses in potatoes.
Transmission of potato viruses by aphids.

CHILE

ESTACION EXPERIMENTAL CENTINELA, PUERTO OCTAY, CHILE
S. Gaona
VIRUS DISEASES — Certification program.
E. Oehrens
VIRUS DISEASES — Virus A, X, leaf roll.

MINISTERIO DE AGRICULTURA, DEPTO. DE DEFENSA AGRICOLA CASILLA 4647, SANTIAGO, CHILE
M. Vallejo
NEMATODES — Rot-knot.

MINISTERIO DE AGRICULTURA, DEPTO. PRODUCCION AGRARIA, CASILLA 5577, SANTIAGO, CHILE
F. Mujica
FUNGUS DISEASES — Late blight.
Sra. Carmen Sanz
TAXONOMY — Cytogenetics.

UNIVERSIDAD DE CHILE, ESTACION EXPERIMENTAL AGRONOMICA, MAIPU, CHILE
P. Carmona
PHYSIOLOGY — Irrigation experiments.
E. Letelier
PHYSIOLGY — Nutrition.
Alvaro Montaldo (Department Head)
BREEDING — Disease resistance—late blight, common scab, powdery scab.
TAXONOMY — Species collection.

COLOMBIA

CENTRO NAL DE INVESTIGACIONES AGRICOLAS, "TIBAITATA," APARTADO AEREO 58-13, BOGOTA, COLOMBIA, SOUTH AMERICA

Vicente Alba and Lauro Lujan
VIRUS DISEASES — Viruses X, Y, Aucuba mosaic, leaf roll, veinal yellows.

Julia Guzman
FUNGUS DISEASES — Late blight—culture, strains, resistance.
Early blight—resistance.

Lee Heidrick
FUNGUS DISEASES — Late blight—strains, culture, inoculation technique.
VIRUS DISEASES — Viruses X, Y, and leaf roll.

Ernesto Knot
QUALITY — Tuber rots—Fusarium and Phytophthora.

Edmundo Perez and Nelson Estrada
BREEDING — Resistance to late blight, viruses X, Y, leaf roll, and frost.

Lazaro Posada
INSECTS — Foliage and tuber.

PERU

ESTACION EXPERIMENTAL AGRICOLA, DE LA MOLINA, LIMA, PERU

Lily R. Brown V., Depto. de Fitopatologia and R. Vargas S., Depto. de Agronomia
VIRUS DISEASES — Study of virus diseases in the potato crop of Peru.

Lily R. Brown V., and S. Dongo D., Depto. de Fitopatologia
VIRUS DISEASES — Occurrence of virus X in the potato producing areas.

Victor Revilla M., Depto. de Fitopatologia and C. Llosa B., Depto. de Agronomia
FUNGUS DISEASES — Fungicide test.

R. Vargas S. and Lily R. Brwon, Depto. de Fitopatologia
QUALITY — Production of selected potato seed.

M. Llaveria, Depto. de Agronomia and Ing° J. Calzada B. — Planes Experimentales — PECEA
QUALITY — Fertilizing formulas.

A. Quevedo, Depto. de Genetica
BREEDING — Creating new varieties by breeding.
FUNGUS DISEASES — Resistance to late blight.

J. Simon, Depto. de Entomology
INSECTS — Insecticide tests. Chemical control of *Heterodera rostochiensis*.

J. Simon, Depto. de Entomology, and R. Montalvo, Depto. de Agronomia
INSECTS — Test with organic insecticides against the Andean potato bug (*Premnotrypes solani*).

PROGRAMA COOPERATIVO DE EXPERIMENTACION AGROPECUARIA, PROGRAMA DE PAPA, EDIFICIO MINISTERIO DE TRABAJO 10°, PISO, LIMA, PERU

Carlos Ochoa
BREEDING — Genetics—disease resistance.
TAXONOMY — Species collection and hybridization.

UNIVERSIDAD DE CUZCO, DEPARTMENT OF BOTANY, CASILLA 79, CUZCO, PERU

Cesar Vargas C.
TAXONOMY — Cultivated and wild *Solanum* species. Collection of species, varieties, and forms, of South-Peru cultivated potatoes. Geographical distribution and ecological distribution of potatoes of South-Peru.
Herbaria colection of about 2000 sheets of cultivated potatoes of South-Peru, also herbaria specimens of wild species from the same region, many TYPE species, etc.

CENTRO NACIONAL DE INVESTIGATION, EXPERIMENTACION AGRICOLA, DE LA MOLINA, LIMA, PERU

C. Bazan de Segura
FUNGUS DISEASES — Late blight.

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